AD-A094 371 NATHAN (ROBERT R) ASSOCIATES INC WASHINGTON D C F/G 5/3

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER--ETC(U)

DEC 80 DACW69-78-C-0136

UNCLASSIFIED NL

1 OF 1

AD A
094371

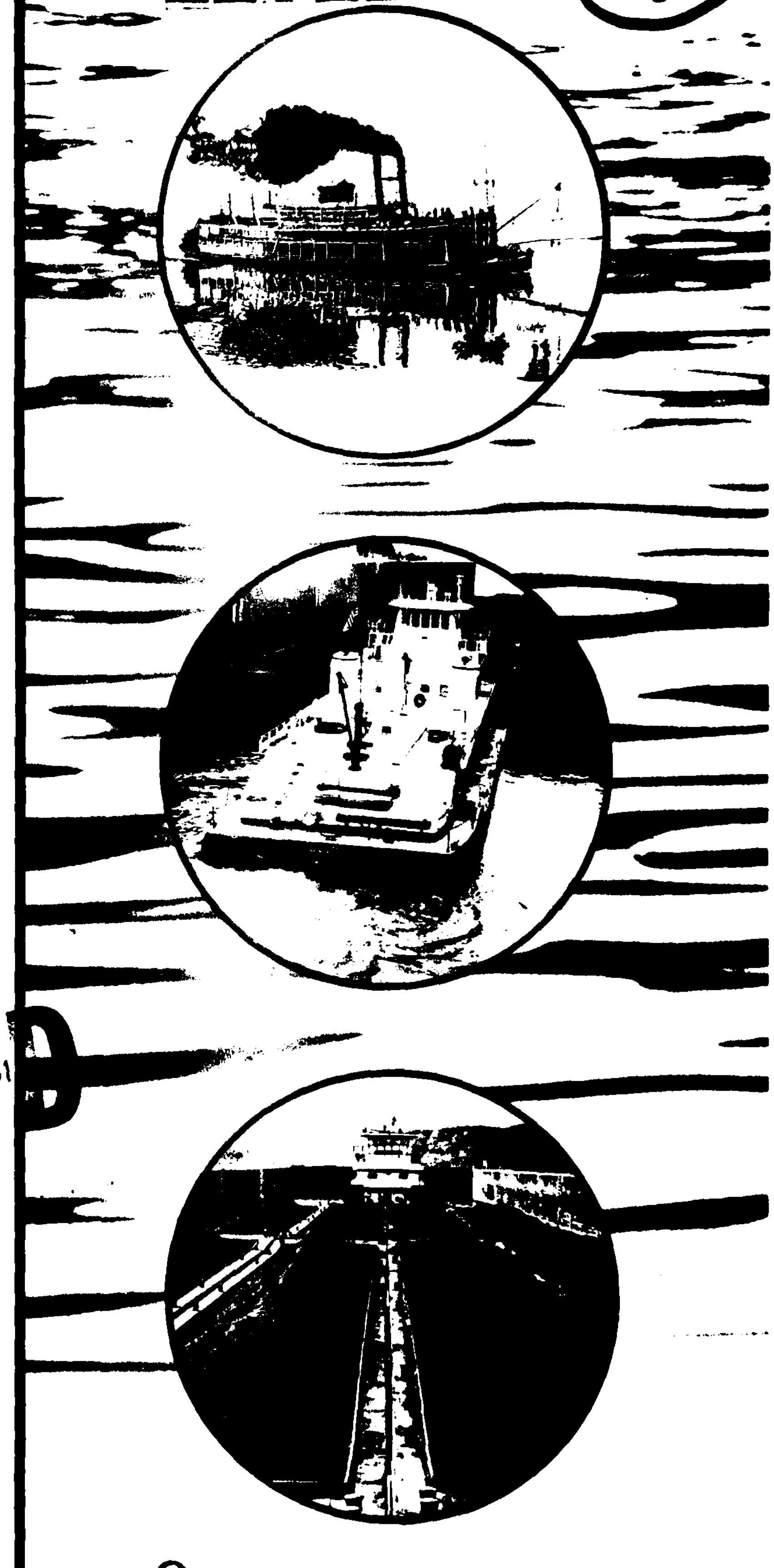
END

DATE
FILMED

2-81

DTIC

LEVEL III (12)



Projections Of Demand For Waterborne Transportation

Ohio River Basin 1980 - 2040

Volume 15

Nonferrous Metals and Alloys, Nec.

U. S. Army Corps of Engineers
Ohio River Division
Cincinnati, Ohio

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER	2. GOVT ACCESSION NO. AD-A094 371
3. RECIPIENT'S CATALOG NUMBER	
4. TITLE (and Subtitle) Projections of Demand for Waterborne Transportation, Ohio River Basin 1980, 1990, 2000, 2020, 2040; Vol. 15, Group XIII Nonferrous Metals and Alloys, Nec.	5. TYPE OF REPORT & PERIOD COVERED Vol. 15 of 17
	6. PERFORMING ORG. REPORT NUMBER
7. AUTHOR(s)	8. CONTRACT OR GRANT NUMBER(s) DACW69-78-C-0136
9. PERFORMING ORGANIZATION NAME AND ADDRESS Robert R. Nathan Associates, Inc. Consulting Economists 1301 Pennsylvania Ave., N.W. Washington, DC 20004	10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS Ohio River Basin Navigation Studies
11. CONTROLLING OFFICE NAME AND ADDRESS U.S. Army Corps of Engineers, Ohio River Div. ATTN: Navigation Studies Branch, Planning Div. P.O. Box 1159, Cincinnati, OH 45201	12. REPORT DATE December 1980
	13. NUMBER OF PAGES 57
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) U.S. Army Corps of Engineers, Huntington District P.O. Box 2127 Huntington, WV 25721	15. SECURITY CLASS. (of this report) Unclassified
	15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Approved for Public release; distribution unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

18. SUPPLEMENTARY NOTES

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

Bulk cargo	Market demand analysis	Metals
Commodity resource inventory	Modal split analysis	Nonferrous metals
Economic development	Ohio River Basin	Alloys
Economic forecasting	River basin development	
Inland waterways	Traffic surveys	

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System. Each of the studies considers existing waterborne commerce and develops a consistent set of projects of future traffic demands for all of the navigable waterways of the Basin. Each report contains information on past and present waterborne commerce in the Basin and projections by commodity groups and origin-destination areas from 1976 to at least 1990.

DD FORM 1 JAN 73 1473 EDITION OF 1 NOV 65 IS OBSOLETE

Unclassified
SECURITY CLASSIFICATION OF THIS PAGE (When Data Entered)

(Continued from #20)
The three study projections, in conjunction with other analytical tools and system information, will be used to evaluate specific waterway improvements to meet short and long-term navigation needs. The output from these studies will serve as input to Corps' Inland Navigation Simulation Models to help analyze the performance and opportunities for improvement of the Ohio River Basin Navigation System. These data will be used in current studies relating to improvement of Gallipolis Locks, the Monongahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, the Cumberland River and the Tennessee River, as well as other improvements.

This document is volume 15 of the 17 volume report shown below.

The study included a Commodity Resource Inventory, a Modal Split Analysis and a Market Demand Analysis. The work included investigation and analyses of the production, transportation and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of and within the Ohio River Basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A study summary aggregates the commodity group totals for each of the several projections periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin. The study results are presented in the following 17 documents:

Volume	Subject Title	
1	Study summary	
2	Methodology	
3	Group I:	Coal and coke
4	Group II:	Petroleum fuels
5	Group III:	Crude Petrol.
6	Group IV:	Aggregates
7	Group V:	Grains
8	Group VI:	Chemicals and chemical fertilizers
9	Group VII:	Ores and Minerals
10	Group VIII:	Iron ore, steel and iron
11	Group IX:	Feed and food products, nec.
12	Group X:	Wood and paper products
13	Group XI:	Petroleum products, nec.
14	Group XII:	Rubber, plastics, nonmetallic, mineral, products, nec.
15	Group XIII:	Nonferrous, metals and alloys, nec.
16	Group XIV:	Manufactured products, nec.
17	Group XV:	Other, nec.

Additionally, an Executive Summary is available as a separate document.

(9) Final Rept. (

GROUP XIII, NONFERROUS METALS AND ALLOYS, NEC.

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION, OHIO RIVER BASIN, 1980, 1990, 2000, 2020, 2040. Volume 15.

Prepared for

U.S. ARMY CORPS OF ENGINEERS
OHIO RIVER DIVISION, HUNTINGTON DISTRICT

(15) Contract No. DACW69-78-C-0136

by

Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

(11) DECEMBER 1980

(12) 63

Accession For	
NTIS GRA&I	X
DTIC TAB	
Unannounced	
Justification	
By	
Distribution/	
Availability Codes	
Dist	Avail and/or Special
A	

407...

A limited supply of this report is available at cost (please prepay, with checks payable to the United States Treasurer) from:

Division Engineer
U.S. Army Engineer Division, Ohio River
ATTN: ORDAS
P.O. Box 1159
Cincinnati, OH 45201

The price of the several documents of the report is as follows:

Executive Summary:	no charge
Volume 1:	$4.00
Volumes 2, 3, 7 and 10:	$3.00 each
All Others:	$2.00 each

The entire set of 17 volumes: $40.00

An unlimited supply of this report will soon be available from:

National Technical Information Service (NTIS)
U.S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

Library cataloging information:

Robert R. Nathan Associates, Inc.
Projections of demand for waterborne transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040 / Prepared for the U.S. Army Corps of Engineers, Huntington District ... by Robert R. Nathan Associates, Inc., December 1980. Cincinnati, Ohio : U.S. Army Corps of Engineers, Ohio River Division, 1980.
17 v. : ill. ; 28 cm.
Contract DACW69-78-0136.
"...one of three independent but complementary studies of future freight traffic on the Ohio River Basin Navigation System."

CONTENTS: v.1. Study summary.--v.2. Methodology.--v.3. Commodity groups .

1. Shipping--Ohio River Basin. 2. Inland water transportation--Ohio River Basin--Statistics. 3. Ohio River Basin. I. United States. Army. Corps of Engineers. Ohio River Division. II. United States. Army. Corps of Engineers. Huntington District. III. Title.

HE597.03N3 OCLC no. 7030444

PREFACE

This Corps of Engineers report describes one of three independent but complementary studies of future freight traffic on the Ohio River basin navigation system. Each of the studies considers existing waterborne commerce and develops a consistent set of projections of future traffic demands for all of the navigable waterways of the basin. Each report contains information on past and present waterborne commerce in the basin with projections by commodity group and origin-destination areas from 1976 to either 1990 or 2040.

The three projections, in conjunction with other analytical tools and waterway system information, will be used to evaluate specific waterway improvements required to meet short and long-term navigation needs. The output from these studies will serve as input to Corps inland navigation simulation models to help analyze the performance and requirements for improvements of the Ohio River basin navigation system. These data will be used in current studies relating to improvements of Gallipolis Locks, the Monorgahela River, the Upper Ohio River, the Kanawha River, the Lower Ohio River, and the Tennessee River, as well as for other improvements.

The reports on the three studies are referred to as the "CONSAD," the "BATTELLE," and the "NATHAN" reports. The latter and final report was completed in November 1980. It was prepared for the Corps of Engineers by Robert R. Nathan Associates, Inc., Consulting Economists, Washington D.C. This study encompasses the period 1976-2040, and is by far the most detailed of the three.

The "CONSAD" report, completed in January 1979, was prepared for the Corps by the CONSAD Research Corporation of Pittsburgh, Pennsylvania. The study and the 1976-1990 projected traffic demands discussed in that report were developed by correlating the historic waterborne commodity flows on the Ohio River navigation system, with various indicators of regional and national demands for the commodities. The demand variables which appeared to best describe the historic traffic pattern for each of the commodity groups was selected for projection purposes. The projected values for the demand variables are based upon the 1972 OBERS Series E Projections of National and Regional Economic Activity. The OBERS projections serve as national standards and were developed by the Bureau of Economic Analysis of the U.S. Department of Commerce, in conjunction with the Economic Research Service of the Department of Agriculture.

The "BATTELLE" report was completed in June 1979, and was prepared for the Corps by the Battelle Columbus Laboratories, Columbus, Ohio. The study and the 1976-1990 traffic projections discussed in that report were developed by surveying all waterway users in the Ohio River Basin through a combined mail survey and personal interview approach. The purpose of the survey was to obtain an estimate from each individual shipper of his future commodity

movements, by specific origins and destinations, as well as other associated traffic information. All identifiable waterway users were contacted and requested to provide the survey information. In addition, personal interviews were held with the major shippers. The responses were then aggregated to yield projected traffic demands for the Ohio River navigation system.

The "NATHAN" report presents the findings of a commodity resource inventory, a modal split analysis and a market demand analysis. The work included investigation and analyses of the production, transportation, and demand characteristics of each of the major commodities transported on the Ohio River and its tributaries. For each of 15 commodity groups, the demand for waterway transportation into, out of, and within the Ohio River basin was projected through the year 2040. A detailed study analysis and discussion for each commodity group is presented in 15 individually bound reports, supplemented by a methodology report. A Study Summary and an Executive Summary present appropriately abbreviated discussion and findings resulting from these analyses. The Study Summary aggregates the commodity group totals for each of the several projection periods and lists the total waterborne commerce for each of the 72 operational locks and dams in the Ohio River Basin.

The "NATHAN" report, "Projections of Demand for Waterborne Transportation, Ohio River Basin, 1980, 1990, 2000, 2020, 2040" consists of the following volumes:

Subject Title	Number of Pages	Volume Number
Study Summary	220	1
Methodology	118	2
Group I: Coal and Coke	134	3
Group II: Petroleum Fuels	66	4
Group III: Crude Petroleum	42	5
Group IV: Aggregates	64	6
Group V: Grains	131	7
Group VI: Chemicals and Chemical Fertilizers	90	8
Group VII: Ores and Minerals	61	9
Group VIII: Iron Ore, Steel and Iron	104	10
Group IX: Feed and Food Products, Nec.	44	11
Group X: Wood and Paper Products	61	12
Group XI: Petroleum Products, Nec.	38	13
Group XII: Rubber, Plastic, Nonmetallic Mineral Products, Nec.	41	14
Group XIII: Nonferrous Metals and Alloys, Nec.	57	15
Group XIV: Manufactured Products Nec.	35	16
Group XV: Others, Nec.	48	17

Additionally, an Executive Summary is available as a separate document.

RRNA

PROJECTIONS OF DEMAND FOR WATERBORNE TRANSPORTATION OHIO RIVER BASIN 1980, 1990, 2000, 2020, 2040

Group XIII: Nonferrous Metals and Alloys, Nec.

Prepared for
U.S. Army Corps of Engineers
Huntington District
Contract No. DACW69-78-C-0136

by
Robert R. Nathan Associates, Inc.
Consulting Economists
Washington, D.C.

November 1980

TABLE OF CONTENTS

Page

I. INTRODUCTION

Group XIII, nonferrous metals and alloys, nec., consists of primary smelter products and semi-fabricated products, such as sheets, bars, castings and wire, and other mill and foundry products. These products contribute only a small portion of the total waterborne traffic in the Ohio River System (ORS). In 1976, for instance, total Group XIII movements accounted for only 0.1 percent of the total waterborne commerce in the ORS.

The areas within the Ohio River Basin (ORB) for which projections of Group XIII consumption, production and movements have been made are designated as Primary Study Areas (PSAs). The PSAs for Group XIII are those U.S. Department of Commerce Bureau of Economic Analysis Areas (BEAs) which are ORB origins or destinations of Group XIII waterborne movements. A map showing Group XIII PSAs is presented in the appendix to this report.

In addition to the PSAs, external areas which are linked to the ORB through waterborne commerce have been identified. Areas (BEAs) outside the ORB which are destinations of waterborne Groups XIII movements originating in the ORB are designated as Secondary Consumption Areas (SCAs). Areas (BEAs) outside the ORB which are origins of Group XIII waterborne movements destined to the ORB are designated as Secondary Production Areas (SPAs).

A. Description of Group XIII

The individual products included in Group XIII are:

Waterborne Commerce Statistics Code (WCSC)	Commodity/Product
3321	Nonferrous metals, primary smelter products,

	basic shapes, wire, castings and forgings, except copper, lead, zinc and aluminum
3322	Copper and copper alloys, whether or not refined, unworked
3323	Lead and zinc industry alloys, unworked
3324	Aluminum and aluminum alloys, unworked.

Of these four product classifications, three (copper and copper alloys, lead and zinc and alloys, and aluminum and alloys) constitute the major portion of Group XIII waterborne traffic. In 1976, 244.8 of the 246.9 thousand tons of nonferrous metals and alloys which moved by water were products of copper, aluminum, lead or zinc (Table 1). Only 32.3 thousand tons of other primary smelter products were transported in the ORS during the entire 1969-76 period.

A-1. Aluminum and Alloys

The movements of primary smelter and semi-fabricated products of aluminum in the ORS have been increasing both in absolute and relative terms. The total volume of waterborne aluminum product movements increased from 1.2 thousand tons in 1969 to 142.7 thousand tons in 1976 (Table 1). The aluminum share of the total nonferrous metal waterborne movements increased from 3.0 percent in 1969 to 57.8 percent in 1976.

A-2. Copper and Copper Alloys

The volume of waterborne copper products in the ORS increased from 1.7 thousand tons in 1969 to 20.8 thousand tons in 1976. Copper's share of total nonferrous waterborne commerce also increased, from 4.0 percent to 8.0 percent, during the same period. It should be pointed out, however, that the copper share of the total nonferrous metal waterborne movements began to decline in 1974.

Table 1. Ohio River System: Waterborne Shipments of Nonferrous Metals and Alloys, Nec., by Product Inbound, Outbound, and Local Movements, 1976-76

(Thousands of tons unless otherwise specified)

Product and type of movements	1969	1970	1971	1972	1973	1974	1975	1976	Average annual percentage change, 1969-76
Total	41.6	43.1	117.9	103.2	72.5	88.9	181.7	246.9	29.0
Inbound	29.2	29.5	92.8	84.7	55.6	36.9	81.6	215.0	33.0
Outbound	2.3	5.5	4.1	5.4	8.0	21.5	38.6	11.1	25.2
Local	10.0	8.1	21.0	13.1	8.8	30.5	61.5	20.8	11.0
Primary smelter products	1.7	0.9	2.2	4.1	1.0	17.5	2.8	2.1	3.1
Inbound	--	0.3	1.0	4.1	1.0	--	--	2.1	a
Outbound	--	--	--	--	--	17.5	2.8	--	--
Local	1.7	0.6	1.2	--	--	--	b	--	--
Copper and copper alloys	1.7	0.3	9.8	1.4	3.2	29.7	50.3	20.8	43.0
Inbound	--	--	--	1.4	0.5	1.8	--	3.3	a
Outbound	1.7	0.3	--	--	1.3	--	--	--	--
Local	--	--	9.8	--	1.4	27.9	50.3	17.5	a
Lead and zinc and lead and zinc alloys	37.0	40.6	52.1	59.4	48.0	33.4	75.3	81.3	11.9
Inbound	28.7	27.9	42.6	46.9	35.5	29.7	46.9	78.0	15.4
Outbound	--	5.2	2.8	--	5.1	1.1	19.1	2.2	a
Local	8.3	7.5	6.7	12.5	7.4	2.6	8.5	1.1	(25.1)
Aluminum and aluminum alloys	1.2	1.2	53.8	38.4	20.3	8.2	53.3	142.7	97.9
Inbound	0.5	1.2	49.2	32.3	18.7	5.3	34.8	131.6	121.7
Outbound	0.7	--	1.3	5.4	1.6	2.9	15.9	8.9	43.8
Local	--	--	3.3	0.7	--	--	2.6	2.2	a

Note: Individual items may not add to totals due to rounding.
a. No movements in 1969.
b. Less than 50 tons.
Source: Compiled by RRNA from Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

A-3. Lead and Zinc, and Their Alloys

Lead and zinc products included in this study are essentially comprised of primary metals. Semi-fabricated products of lead and zinc are relatively insignificant in terms of tonnage.

While the volume of lead and zinc transported in the ORS increased moderately between 1969 and 1976, their share of total nonferrous metal waterborne movements decreased dramatically, from 89.0 percent in 1969 to 32.9 percent in 1976.

A-4. Other Nonferrous Metals and Alloys

Primary smelter products of other nonferrous metals, such as tin, magnesium, nickel, chromium and other minor nonferrous metals, constitute another minor product group in terms of waterway traffic. Products of this group accounted for only 2.1 thousand tons of total nonferrous metal waterborne movements in 1969, and the group share remained small (1 percent) in 1976.

B. Existing Waterway Traffic Flows

In 1976, Group XIII accounted for 0.12 percent of total ORS traffic (Table 2) the bulk of which was inbound traffic (Table 1). Between 1969 and 1976, the volume of Group XIII waterborne traffic increased almost sixfold (Table 1). It increased from 41.6 thousand tons in 1969 to 246.9 thousand tons in 1976. A large increase occurred in 1971, providing a volume of traffic almost triple that of 1970.

In spite of a general growth trend, the volume of traffic between 1969 and 1976 fluctuated widely. For instance, after a big surge in 1971, total traffic dropped in 1972 and 1973 and then rebounded in 1975. These patterns pertained to inbound and outbound as well as local movements. One explanation is that, because of the relatively small volumes of nonferrous metals which move in the river system, an occasional increase or decrease of a few barges had a substantial impact on total traffic volume.

B-1. BEA-to-BEA Traffic Flows

During the 1969-76 period, the inbound shipments of Group XIII products (traffic from a port equivalent (PE) outside the ORB to a

Table 2. Ohio River System: Waterborne Shipments of All Commodities and of Nonferrous Metals and Alloys, 1976

(Thousands of tons unless otherwise specified)

	Total	Inbound	Outbound	Local
All commodities	200,770.5	29,439.5	26,854.0	144,477.0
Nonferrous metals and alloys	246.9	215.0	11.1	20.8
As a percentage of all commodities	0.12	0.73	0.04	0.01

Source: Compiled by RRNA from *Waterborne Commerce by Port Equivalents*, revised 1976, supplied by U.S. Army Corps of Engineers.

PE within the ORB) increased at an average annual rate of 33.0 percent. This increase accounted for more than 87 percent of total nonferrous metal movements in the ORS in 1976. The bulk of these movements were aluminum and aluminum alloys. Throughout the period, inbound traffic was the predominant type of traffic.

BEA 49 (Nashville) received 65.6 thousand tons of inbound nonferrous metals and alloys in 1976. Although not a major consumer of aluminum, BEA 49 consumed significant amounts of primary lead, copper and mill and foundry products. Most BEA 49 receipts originated from Gulf Coast areas, as was the case for most inbound traffic (Table 3).

BEA 52 (Huntington) received 53.6 thousand tons in 1976, all from points outside the ORB. No shipments from BEA 52 were reported in 1976 and most other years during the period 1969-76.

BEA 66 (Pittsburgh) received 44.0 thousand tons of waterborne nonferrous metals and alloys in 1976. Of these movements, 27.7 was inbound traffic, which the remainder was local traffic. More than 78 percent of local ORS traffic was shipped to BEA 66. Pittsburgh, a major producer and consumer of nonferrous metals and alloys in the ORB, was also the leading ORB shipper of Group XIII products in 1976, with shipments totalling 19.7 thousand tons.

Other BEAs contributed insignificant amounts to ORS waterborne traffic. Less than 31 percent of total waterborne receipts in the ORB was distributed among BEAs 62 (Cincinnati), 55 (Evansville) and 48 (Chattanooga). Only BEA 66 (Pittsburgh), with 19.7 thousand tons, and BEA 49 (Nashville), with shipments of 10 thousand tons, shipped more than 5 thousand tons.

B-2. Highlights of Important Links

Inbound traffic accounted for almost 87.1 percent of the total waterborne nonferrous metal movements in the ORS in 1976. It can be seen from Table 1 that the bulk of the inbound traffic (97.5 percent) was composed of aluminum, lead and zinc products, with copper accounting for an insignificant 1.5 percent of the inbound traffic. Most inbound shipments were from Gulf Coast PEs to BEAs 49 (Nashville) and 52 (Huntington).

Although the volume of outbound traffic increased during the period of 1969 to 1976, outbound movements as a percentage of total nonferrous metal traffic were small. They accounted for only 4.5

Table 3. Ohio River Basin: Waterborne Commerce by BEA, 1976
Group 13: Nonferrous Metals and Alloys, Nec.

(Thousands of tons)

Origin	Destination										
	Total	ORB BEAs	BEA 48	BEA 49	BEA 52	BEA 55	BEA 62	BEA 66	Non-ORB BEAs	BEA 138	BEA 140	BEA 141
TOTAL	246.9	235.8	21.2	65.6	53.6	23.6	27.8	44.0	11.1	1.1	7.8	2.2
ORB BEAs	31.9	20.8	--	--	--	--	4.5	16.3	11.1	1.1	7.8	2.2
BEA 49	10.0	2.2	--	--	--	--	--	2.2	7.8	--	7.8	--
BEA 55	2.2	1.1	--	--	--	--	--	1.1	1.1	1.1	--	--
BEA 66	19.7	17.5	--	--	--	--	4.5	13.0	2.2	--	--	2.2
Non-ORB BEAs	215.0	215.0	21.2	65.6	53.6	23.6	23.3	27.7				
BEA 77	1.1	1.1	1.1	--	--	--	--	--				
BEA 114	27.8	27.8	15.6	--	5.6	3.3	--	3.3				
BEA 133	3.3	3.3	--	3.3	--	--	--	--				
BEA 138	77.8	77.8	4.5	3.3	48.0	17.0	--	5.0	**Traffic external to Ohio River System**			
BEA 140	60.1	60.1	--	59.0	--	--	--	1.1				
BEA 141	4.3	4.3	--	--	--	3.3	--	1.0				
BEA 143	34.0	34.0	--	--	--	--	20.0	14.0				
BEA 144	6.6	6.6	--	--	--	--	3.3	3.3				

Source: U.S. Army Corps of Engineers, Waterborne Commerce by Port Equivalents, revised 1976.

percent of the total nonferrous metal waterborne traffic in 1976. It is important to note that the greater part of outbound nonferrous metal traffic (80.2 percent) was made up of aluminum products. The rest consisted of zinc products. In 1976, only three BEAs received waterborne shipments of nonferrous metals and alloys from the ORB: BEAs 138 (New Orleans), 140 (Beaumont) and 141 (Houston).

Local traffic within the ORS in 1976 accounted for approximately 4.4 percent of the total ORS waterborne nonferrous metal traffic. As indicated in Table 1, almost 85 percent of the local traffic consisted of copper products; while the remainder consisted of lead, zinc and aluminum products. Most local movements were shipped and received in BEA 66 (Pittsburgh).

C. Summary of Study Findings

Projections of production, consumption, modal split and waterborne traffic in the ORB have been made through the year 2040. Production is projected to increase at a faster rate than consumption, with waterborne shipments increasing at a rate slightly above the rate for consumption.

C-1. Production

Production of Group XIII products in the PSAs is expected to increase rapidly in the future, from 2,771.2 thousand tons in 1976 to 25,236.1 thousand tons in 2040. Of all the nonferrous metals, aluminum is the most important in the area served by the ORS. In 1976, aluminum products accounted for 85 percent of total nonferrous metal products produced in the area. Aluminum's share of total nonferrous metal production is likely to be even greater in the future.

C-2. Consumption

Consumption of primary nonferrous metal products in the PSAs is expected to grow at an average annual rate of 2.7 percent, from its 1976 level of 1,464.9 thousand tons to 7,893.2 thousand tons in 2040. As in the case of production, the consumption of primary aluminum products constitutes the bulk of total primary nonferrous products consumed in the PSAs. Aluminum's share of total consumption is also expected to increase in the future.

C-3. Modal Split

Water transport is an insignificant mode of transport for primary nonferrous metal products in the area served by the ORS. In 1976, waterborne nonferrous traffic accounted for only a small percent of gross nonferrous metal product shipments. Waterborne movements of nonferrous metals are projected to remain insignificant. The existing modal split is unlikely to change within the foreseeable future.

C-4. Waterway Traffic Flows

The future level of waterborne nonferrous primary metal products in the ORS is projected to reach 1,567.8 thousand tons in 2040, increasing from 246.9 thousand tons in 1976. The existing waterborne traffic for nonferrous metal products mainly consists of primary smelter products. This composition of nonferrous traffic is expected to remain unchanged in the future.

II. MARKET DEMAND ANALYSIS

Consumption of nonferrous metals and alloys in the PSAs did not increase significantly during the period 1969-76. This reflects relatively moderate growth of consuming industries, which is expected to continue into the future.

A. Market Areas

In addition to local demand for Group XIII products produced in the PSAs, demand also is generated by Secondary Consumption Areas (SCAs) located outside the ORB. These SCAs are defined as BEAs that are the destinations of waterborne nonferrous metals and alloys, nec., movements originating in the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

This study has identified seven BEA and BEA segments in the ORB that have been or will be origins or destinations for Group XIII waterborne movements. Appendix Table A-1 presents the BEAs and BEA segments which constitute the PSAs for nonferrous metals and alloys, and for which nonferrous metals and alloys consumption has been analyzed and projected.

a. Primary Metals

Of all the primary nonferrous metals, aluminum is by far the most important in terms of tonnage consumed. Aluminum's share of total consumption in the PSAs was 50.7 percent in 1976. The consumption of copper, lead, and zinc was relatively insignificant; their shares of total primary nonferrous metal consumption in 1976 were 14.1, 3.5 and 3.6 percent, respectively. Other nonferrous metals, although insignificant individually, constituted an important share (28.1 percent) of total nonferrous metal consumption.

<u>Primary Aluminum</u>: Consumption of primary aluminum metal was concentrated in a few BEAs. Two of the seven BEA segments that compose the PSAs consumed 59 percent of the total primary aluminum consumed in the area served by the ORS (Table 4).

The largest aluminum consumption area was BEA 52 (Huntington), which accounted for 32 percent of total aluminum consumption in 1976. BEA 55 (Evansville) trailed BEA 52 as the second largest consuming PSA for primary aluminum metal. Although the other PSAs accounted for about 40 percent of total aluminum consumption in PSAs, their individual shares were negligible.

<u>Primary Copper</u>: Four of the seven PSAs represented all of the primary copper consumption. Of these four BEAs, BEA 66 (Pittsburgh) accounted for 46 percent of the total consumption in the PSAs. The percentage shares of total primary copper consumption in other PSAs were: BEA 48 (Chattanooga), 23.1 percent; BEA 49 (Nashville), 23.1 percent; and BEA 62 (Cincinnati), 7.7 percent.

<u>Primary Lead and Zinc</u>: While primary aluminum and copper are processed by fabricators before they reach their end-use markets, lead and zinc are consumed directly by some end-use industries. Consequently, consumption of lead and zinc does not tend to be geographically concentrated.

Most of the PSAs consume primary lead. The major consumption areas and their shares of total consumption are as follows: BEA 66 (Pittsburgh), 51.0 percent; BEA 49 (Nashville), 14.2 percent; BEA 62 (Cincinnati), 12.2 percent; and other BEAs, 22.6 percent.

Each of the PSAs also consumes primary zinc. The major consumption areas of primary zinc and their percentage shares of the total consumption are: BEA 62 (Cincinnati), 36.0 percent; BEA 49 (Nashville), 21.2 percent; BEA 66 (Pittsburgh), 14.8 percent; BEA 55 (Evansville), 12.7 percent; and other BEAs, 15.3 percent.

<u>Other Primary Nonferrous Metals</u>: Due to its predominant position in steel and other primary metal production, BEA 66 (Pittsburgh) is by far the single largest consumption area of minor nonferrous metals. In 1976, BEA 66 alone accounted for approximately 67 percent of total minor nonferrous metals consumed in the PSAs. Other major consumption areas were BEA 52 (Huntington), 9.9 percent, and BEA 62 (Cincinnati), 8.0 percent.

Table 4. Ohio River Basin: Consumption of Nonferrous Metals and Alloys,[a] by BEAs or BEA Segments,[b] and by Commodities, Estimated 1976

(Thousands of tons)

BEA or BEA segment	Aluminum: Primary metal	Aluminum: Mill and foundry products	Copper: Primary metal	Copper: Mill and foundry products	Primary lead	Slab zinc	Other primary nonferrous metals
Primary Study Areas	513.5	229.5	51.9	154.9	50.6	53.4	411.1
BEA 48: Chattanooga, TN	34.2	16.8	12.0	20.1	3.1	4.5	19.1
BEA 49: Nashville, TN	73.4	39.2	12.0	34.4	7.2	11.3	10.9
BEA 50: Knoxville, TN	--	5.6	--	5.7	2.1	2.6	13.6
BEA 52: Huntington, WV	166.3	11.2	--	5.7	4.1	1.1	40.8
BEA 55: Evansville, IN	136.9	33.6	--	31.6	2.1	6.8	19.1
BEA 62: Cincinnati, OH	44.0	67.1	4.0	25.8	6.2	19.2	32.7
BEA 66: Pittsburgh, PA	58.7	56.0	23.9	31.6	25.8	7.9	274.9

Note: Consumption of primary aluminum and primary copper by BEA segments was calculated from their individual total U.S. consumption based on the employment distribution of the industries that consume these two primary metals. The employment distribution ratios were obtained by dividing the number of foundry and mill employees in each BEA segment by the total U.S. mill and foundry employment of each of these two metals. Consumption of primary lead, primary zinc, aluminum and copper products was estimated according to the employment distribution of their end-use markets among the BEA segments. Consumption of the remaining metals was calculated according to the employment distribution of the entire primary metal industry among the BEA segments.

a. Includes the primary metal of aluminum, copper, lead, zinc, nickel, titanium, magnesium, tin, antimony, beryllium, chromium, manganese and cadmium and primary products of aluminum, copper and molybdenum.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Sources: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, 1978 ed.; U.S Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1976 ed.; American Metal Market, Metal Statistics, 1978 ed.; The Aluminum Association, Aluminum Statistical Review, 1977 ed.; and U.S. Department of Commerce, Bureau of the Census, County Business Patterns, 1976 ed.

b. Mill and Foundry Products

Mill and foundry products of nonferrous metals, such as sheet, plate, wire, pipe, foil, casting and other semi-fabricated products, represent a large collection of intermediate products which are used in every phase of nearly all manufacturing activities. Major consumption areas of aluminum and copper semi-fabricated products have already been identified and examined. Mill and foundry products of other nonferrous metals are of no real significance.

Since mill and foundry products represent such a large collection of production inputs, every BEA consumes at least some of these products. The amount consumed depends on the level of manufacturing activities in the BEA.

In 1976, approximately 24 percent of all mill and foundry products in the PSAs was consumed in BEA 62 (Cincinnati). Other major consumption areas were BEA 66 (Pittsburgh), BEA 49 (Nashville) and BEA 55 (Evansville). Together, these four BEAs accounted for approximately 83 percent of all the nonferrous mill and foundry products consumed in the PSAs.

A-2. Secondary Consumption Areas (SCAs)

Outbound movements constitute an insignificant portion of the total nonferrous metal waterborne traffic. BEAs outside the ORB which are destinations of waterborne shipments from the ORB were not segmented for this study, nor was any attempt made to analyze or project consumption in these BEAs. According to the data provided by the Corps of Engineers, only three outbound waterborne shipments to SCAs were reported in 1976. One of the shipments, amounting to 7.8 thousand tons of aluminum ingots, originated in BEA 49 (Nashville) and moved to BEA 140 (Beaumont). Aluminum billets (1.1 thousand tons) were shipped from BEA 55 (Evansville) to BEA 138 (New Orleans). The remaining shipment of 2.2 thousand tons of slab zinc was shipped from a primary smelter in BEA 66 (Pittsburgh) to BEA 141 (Houston).

B. Commodity Uses

Major end-use markets of aluminum, copper, lead and zinc are discussed below. End-use markets for other nonferrous metals have not been examined for the following reasons: (1) these metals are numerous and their individual significance is minimal; and (2) the

majority of these nonferrous metals are used in forming alloys with other metals.

B-1. Aluminum

Aluminum, the most common metallic element on the earth, is the dominant nonferrous metal. It is second only to steel in tonnage poured.[1] Aluminum is used widely in all industries because of its special properties: it is light (three times lighter than steel), non-toxic, and easy to form, machine and cast.

Major end-use markets of aluminum include building construction, transportation, consumer durables, electrical machinery and equipment, containers and packaging. The shares of total consumption of aluminum in these industries are as follows: building construction, 23.1 percent; transportation, 21.7 percent; consumer durables, 7.9 percent; electrical machinery and equipment, 10.0 percent; and containers and packaging, 8.1 percent.[2]

B-2. Copper

Uses of copper are similar to those of aluminum. Major end-use markets of copper are building construction, transportation, industrial machinery and equipment, electrical and electronic products. The shares of copper consumption of these major markets are: building construction, 25 percent; transportation, 15.2 percent; industrial machinery and equipment, 16.1 percent; electrical and electronic products, 25.7 percent; and general consumer products, 17.6 percent.[3]

B-3. Lead

Transportation related industries are by far the largest lead consuming industries. According to the U.S. Bureau of Mines, 70 percent of lead consumption was by the transportation related industries.[4] Lead can be divided into two broad category types:

---

1. American Metal Market, Metal Statistics, 1978 ed. (New York: Fairchild, 1978), p. 19.
2. The Aluminum Association, Aluminum Statistical Review, 1977 ed. (Washington, D.C.: The Aluminum Association, n.d.), p. 19.
3. American Metal Market, Metal Statistics, 1978 ed. (New York: Fairchild, 1978), p. 98.
4. U.S. Department of the Interior, Bureau of Mines, Minerals Yearbook, 1975 ed. (Washington, D.C.: GPO, 1977), p. 813.

metallic and chemical. Metallic lead is generally used to alloy with other elements, while chemical lead is used to form chemical compounds.

The uses of lead and their percentage shares are: storage batteries, 54 percent; antiknock gasoline additives, 16 percent; pigments, 6 percent; ammunition, 6 percent; and other metal products and miscellaneous, 18.0 percent.[1]

B-4. Zinc

Because of its special characteristics, including a relatively low melting point and good resistance to corrosion, zinc is widely used in galvanizing, which provides protective coatings for steel, roofing, automobile bodies, etc. Other uses of zinc include the manufacture of castings, brass and bronze products, and rolled zinc.

The construction industry is the largest market for zinc. It accounts for approximately 39 percent of the total zinc consumption in the United States. Another major end-use market for zinc is the transportation industry, which accounts for another 33 percent of the total consumption of zinc. Other end-use markets are electrical equipment (11 percent) and machinery and equipment (4 percent).[2]

C. Consumption Characteristics

Virtually all aluminum and copper is consumed by mills and foundries or by fabricators of the metals. The products of mills and foundries consist of sheets, plates, wires, foils and castings, etc. These semi-fabricated products are, in turn, used as inputs of other manufacturing industries, such as building construction and automobile production.

The consumption patterns of lead and zinc differ slightly from those of aluminum and copper. While a portion of the lead and zinc consumed is processed before it moves to end-users, some lead and zinc is moved directly to the end-use market.

---

1. Ibid., p. 819.
2. U. S. Department of the Interior, Bureau of Mines, Mineral Commodities Profiles: Zinc; MCP 12 (Washington, D.C.: Bureau of Mines, 1978), p. 8.

The minor nonferrous metals are used primarily in forming alloys with other metals. Their mill and foundry uses are insignificant.

C-1. Economic Characteristics

The demand for nonferrous metal products is primarily derived from the demand for other products, such as automobiles, buildings and other consumer durables. The building construction and automotive industries constitute vitally important markets for nonferrous metals. Since these two markets are traditionally dependent on general economic conditions, the demand for nonferrous metal products fluctuates according to the overall performance of the economy.

C-2. Institutional Characteristics

Several government regulations have exerted great impacts on the demand for certain kinds of nonferrous metal products, as well as on substitution patterns among the nonferrous metals. For instance, the Clean Air Act Amendment of 1977, which limits the amount of antiknock additive allowed in gasoline, has reduced the demand for lead. Regulation of lead content in paint has also had an effect on the demand for lead.

To a certain degree, all four major nonferrous metals are competing in the same end-use markets. Recent government regulations seem to favor the demand for aluminum products. For example, in transportation because the automotive industry is shifting to light vehicles (and light materials) to meet mileage requirements set by federal regulations, copper is receiving strong competition from aluminum and plastics. The emphasis on smaller and lighter cars will also reduce the amount of zinc used in diecasting. On the other hand, demand for zinc in galvanizing applications is expected to increase due to emphasis on corrosion protection.

C-3. Technological Characteristics

Demand for nonferrous metal products is directly or indirectly affected by technological advancements. Copper's position in the

electric and electronic product markets is threatened by the increasing use of glass fiber optics.[1] On the other hand, developments in the use of solar energy for air conditioning and water heating may open up new markets for copper consumption in the future.[2]

Future consumption of lead may also be increased by the development of battery-run cars and the trend toward diesel engines.

D. Existing Aggregate Demand

As can be seen in Table 5, after a small decrease in 1970, total U.S. consumption of nonferrous metal products grew from 1971 to 1973. Consumption then declined in 1974 and 1975. A decrease from 24,124 thousand tons in 1973 to 15,952 thousand tons in 1975 is shown in Table 5. This decline was the direct result of a recession caused by the oil embargo in 1973. Consumption began to recover in 1976.

It should be pointed out that demand for zinc received a disproportionately severe blow during the recession. Consumption of primary zinc declined by 14.4 percent in 1974 and suffered further decline of 28.2 percent in 1975.

Consumption of nonferrous metals in the PSAs remained quite stable during the period of 1969 to 1976, growing only from 1,329.7 thousand tons in 1969 to 1,464.9 thousand tons in 1976 (Table 6). The PSAs accounted for approximately 6.7 percent of the total U.S. nonferrous metal product consumption in 1969. This percentage share had changed by less than 1 percent, to 7.2 percent, in 1976.

E. Forecasting Procedures and Assumptions

National consumption projections for nonferrous metals have been made by the U.S. Bureau of Mines. The implicit growth rates in these projections have been compared with projections of national growth rates of real earnings as prepared by the U.S. Department of Commerce for the OBERS Projections.[3] The relationship

---

1. U.S. Department of Commerce, Domestic and International Business Administration, U.S. Industrial Outlook, 1977 ed. (Washington, D.C.: GPO, 1977), p. 92.
2. Ibid., p. 92.
3. U.S. Water Resources Council, OBERS Projections, Series E, 1972 ed., (Washington, D.C.: GPO, 1974), Vol. II.

Table 5. United States: Consumption of Nonferrous Metals and Alloys, Estimated 1969-76

(Thousands of tons)

Commodity	1969	1970	1971	1972	1973	1974	1975	1976
Total	19,703	18,426	18,850	21,245	24,124	22,784	15,952	20,232
Aluminum:								
Primary metal	4,086	3,846	4,318	4,740	5,597	5,653	3,600	4,890
Mill and foundry products[a]	4,584	4,350	4,613	5,469	6,289	5,896	4,228	5,595
Copper:								
Primary metal[b]	2,145	2,042	2,014	2,230	2,411	2,160	1,541	1,995
Mill and foundry products[c]	3,330	2,886	2,995	3,346	3,686	3,147	2,352	2,870
Primary lead[d]	1,053	986	1,035	1,113	1,205	1,175	915	1,033
Primary zinc	1,368	1,187	1,254	1,418	1,504	1,288	925	1,127
Others[e]	3,137	3,129	2,621	2,929	3,432	3,465	2,391	2,722

a. Includes plates, sheets, foils, forgings, extruded shapes, tubings, rods, wires, bars, powder and castings; estimated from shipments.
b. Refined.
c. Includes wires, castings, granular powder and brass mill products.
d. Apparent consumption.
e. Includes antimony, beryllium, cadmium, chromium, magnesium, manganese, molybdenum, nickel, tin, titanium.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, 1972-78; U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1976; American Metal Market, Metal Statistics, 1971-78; The Aluminum Association, Aluminum Statistical Review, 1977.

Table 6. Ohio River Basin: Consumption of Nonferrous Metals and Alloys,[a] by BEAs or BEA Segments,[b] Estimated 1969-76

(Thousands of tons)

BEA or BEA segment	1969	1970	1971	1972	1973	1974	1975	1976
Primary Study Areas	1,329.7	1,261.9	1,248.3	1,398.5	1,610.9	1,609.0	1,136.5	1,464.1
BEA 48: Chattanooga, TN	102.6	95.7	97.7	109.4	125.5	124.4	85.2	109.8
BEA 49: Nashville, TN	156.6	145.1	152.4	171.3	194.8	189.9	138.9	188.4
BEA 50: Knoxville, TN	31.8	30.2	28.3	31.8	36.3	34.5	24.6	29.6
BEA 52: Huntington, WV	129.9	124.2	124.7	138.5	161.8	194.8	150.9	229.2
BEA 55: Evansville, IN	186.3	173.4	183.5	205.1	236.1	240.1	169.0	230.1
BEA 62: Cincinnati, OH	191.1	178.4	182.3	206.5	235.5	222.9	157.3	199.0
BEA 66: Pittsburgh, PA	531.4	514.9	479.4	536.0	620.9	602.4	410.6	478.8

Note: Consumption of primary aluminum and primary copper by BEAs or BEA segments was calculated from total U.S. consumption and the employment distribution of the industries that consume these two primary metals. The employment distribution ratios were obtained by dividing the number of foundry and mill employees in each BEA or BEA segment by the total U.S. mill and foundry employment of each of these two metals. Consumption of primary lead, primary zinc, aluminum and copper products was estimated according to the employment distribution of their end-use markets among the BEA segments. Consumption of the remaining metals was calculated according to the employment distribution of the entire primary metal industry among the BEAs and BEA segments.

a. Includes the primary metal of aluminum, copper, lead, zinc, nickel, titanium, magnesium, tin, antimony, beryllium, chromium, manganese, and cadmium, and primary products of aluminum, copper, and molybdenum.

b. BEA segments are defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, 1972-78 eds.; U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1976; American Metal, Market Statistics, 1971-78 eds.; The Aluminum Association, Aluminum Statistical Review, 1977 ed.; U.S. Department of Commerce, Bureau of the Census, County Business Patterns, 1973, 1974, 1976 eds.

between the growth rates of nonferrous consumption and real earnings for the nation was then used to estimate nonferrous consumption growth rates by BEA. Growth rates in real earnings for each BEA were also estimated by the U.S. Department of Commerce.

E-1. Forecasting Methodology of Bureau of Mines

Projections of total demand for each of the nonferrous metals were estimated from the projected demand of the individual end-use markets. Regression analyses were based on historical trends, on various economic indicators such as gross national product and Federal Reserve Board indexes, and on projections of the economic indicators. The results of the above projections were further modified by different contingency assumptions regarding technology and other factors to create a range of projections. A most probable level of demand was then established based on the knowledge and judgments of the commodity specialists of the Bureau of Mines.

E-2. Assumptions

Several assumptions were made in estimating future consumption of nonferrous metals and alloys. First, it was assumed, during the projection period, that the U.S. economy will not suffer drastic disruptions such as oil embargos or war. Second, consumption patterns of nonferrous metal products were assumed to remain constant in the future. Third, the consumption of mill and foundry products was assumed to change at the same rates as the consumption of primary metals.

F. Probable Future Demand

Projections of future U.S. consumption of nonferrous metal products for the selected years from 1980 to 2040 are shown in Table 7. It can be seen from the table that consumption increases at an average annual growth rate of 4.0 percent, from the 1974-76 average of 19,656 thousand tons to 52,808 thousand tons in 2000. After the year 2000, the average annual growth rate is expected to decrease to 2.1 percent during the period 2000 to 2040. The level of consumption for 2040 is projected to be 119,995 thousand tons.

Consumption of aluminum products is projected to grow at a much faster rate than that of all other nonferrous metal products. The consumption of copper is expected to increase at lesser but, nevertheless, relatively rapid rates (3.0 percent annual average growth between 1976 and 2000, and 1.3 percent between 2000 and

Table 7. United States: Consumption of Nonferrous Metals and Alloys, Estimated average 1974-76 and Projected 1980-2040

(Thousands of tons unless otherwise specified)

Commodity	Estimated average 1974-76	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1974-76—2000	2000-2040
Total	19,656	25,319	38,720	52,808	90,592	119,995	4.0	2.1
Aluminum:								
Primary metal	4,714	6,827	11,667	16,508	30,995	42,576	5.1	2.4
Mill and foundry products[a]	5,240	7,811	13,349	18,888	36,157	50,158	5.3	2.5
Copper:								
Primary metal[b]	1,899	2,216	2,974	3,939	5,628	6,733	3.0	1.3
Mill and foundry products[c]	2,790	3,187	4,287	5,666	8,095	9,684	2.9	1.3
Primary lead[d]	1,041	1,131	1,377	1,623	2,020	2,254	1.8	0.8
Primary zinc	1,113	1,227	1,478	1,729	2,152	2,402	1.8	0.8
Others[e]	2,859	2,920	3,597	4,455	5,545	6,188	1.8	0.8

Note: Projections for consumption from 1980 to 2000 calculated from the projections (for 1985 and 2000) made by Bureau of Mines. Projected consumption for 1980 and 1990 obtained from linear extrapolations based on 1976, 1985 and 2000 estimates. Consumption from 2000 to 2020 assumed to increase equal to three-fifths of the average annual percentage increase in consumption as between 1974-76 average and 2000. Consumption from 2020 to 2040 projected to increase at an average annual rate equal to half the rate projected for 2000-2020. Mill and foundry products assumed to increase at the same rates as primary metals.

a. Includes plates, sheets, foils, forgings, extruded shapes, tubings, rods, wires, bars, powder and castings.
b. Refined.
c. Includes wire mill, foundry casting, granular powder and brass mill products.
d. Apparent consumption.
e. Includes antimony, beryllium, cadmium, chromium, magnesium, manganese, molybdenum, nickel, tin and titanium.

Sources: Consumption figures of 1974-76 average from Table 5. Projections from U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles, 1978 ed.; and U.S. Department of the Interior, Bureau of Mines, Mineral Facts and Patterns, 1975 ed.

2040). The consumption of lead, zinc and other minor nonferrous metals is also expected to increase, but at much slower rates than those of aluminum and copper.

Total consumption of nonferrous metals in the PSAs is expected to increase from 1,464.9 thousand tons in 1976 to 3,575.9 thousand tons in 2000, the average annual rate of growth being 3.8 percent (Table 8). Between 2000 and 2040, the growth rate is projected to decrease to a 2.0 percent annual average. In 2040, PSA consumption is projected to be 7,893.2 thousand tons.

The nonferrous metal product consumption in the PSAs was approximately 7 percent of total U.S. nonferrous metal consumption in 1976 and is projected to remain relatively stable through 2040.

BEAs in which consumption is expected to grow faster than the rate for the nation as a whole are BEA 49 (Nashville), with an average annual growth rate of 4.8 percent, and BEA 48 (Chattanooga), with an average annual growth rate of 4.6 percent projected for the period 1976-2000.

Table 8. Ohio River Basin: Consumption of Nonferrous Metals and Alloys, by BEAs or BEA Segments,[a] Estimated 1976 and Projected 1980-2040

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated 1976	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1976-2000	2000-2040
Primary Study Areas	1,464.9	1,814.0	2,681.2	3,575.9	6,050.3	7,893.2	3.8	2.0
BEA 48: Chattanooga, TN	109.8	143.5	232.0	320.7	567.0	756.2	4.6	2.2
BEA 49: Nashville, TN	188.4	242.6	406.2	576.3	1,057.2	1,435.2	4.8	2.3
BEA 50: Knoxville, TN	29.6	36.8	57.4	78.0	135.5	178.9	4.1	2.1
BEA 52: Huntington, WV	229.2	269.4	360.3	456.7	711.3	888.8	2.9	1.7
BEA 55: Evansville, IN	230.1	290.4	442.8	596.8	1,036.8	1,369.2	4.1	2.1
BEA 62: Cincinnati, OH	199.0	251.1	378.2	509.8	868.6	1,135.8	4.0	2.0
BEA 66: Pittsburgh, PA	478.8	580.2	804.3	1,037.6	1,673.9	2,129.1	3.3	1.8

Note: Figures of 1976 consumption of the BEA segments were used to calculate the future consumption of the BEA segments. Growth rates for the period 1976-2020 for each of the BEA segments were calculated by comparing the projected growth rates of total earnings of the BEAs with the projected growth rates of the consumption of nonferrous metal and alloys of the United States. Consumption by BEA during the period 2020-2040 was projected to increase at an average annual growth rate equal to half the rate projected for the period 2000-2020.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Sources: Consumption figures of 1976 from Table 6. Projections from U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles, 1978 ed.; U.S. Department of the Interior, Bureau of Mines, Mineral Facts and Problems, 1975 ed.; U.S. Water Resources Council, OBERS Projections, 1972 ed., Vol. II.

III. COMMODITY RESOURCE INVENTORY

Production of nonferrous metals and alloys in the PSAs increased substantially during 1969-76, from 1,827.8 thousand tons in 1969 to 2,771.2 thousand tons in 1976. This increase does not reflect a national trend; rather, it illustrates the growing importance of nonferrous metals and alloys production in the areas served by the Ohio River System. Production in the PSAs is projected to increase at an average annual rate of 5.5 percent through the year 2000. This increase will continue during the period 2000-2040 but at the lower average annual rate of 2.4 percent.

A. Production Areas

The production of Group XIII products in the PSAs is supplemented by production in Secondary Production Areas (SPAs) located outside the Ohio River Basin. These SPAs are defined as BEAs that are origins for Group XIII waterborne movements destined to the Ohio River Basin.

A-1. Primary Study Areas (PSAs)

Production of nonferrous metals and alloys is concentrated in six of the seven PSAs. Altogether, these six PSAs accounted for approximately 96 percent of the total nonferrous metal production in 1976.

Of these six PSAs, BEA 55 (Evansville) and BEA 66 (Pittsburgh) are the largest production areas. The two BEAs together provide approximately 50 percent of total production in the PSAs. The other major PSA production areas are BEA 50 (Knoxville), BEA 52 (Huntington), BEA 48 (Chattanooga) and BEA 49 (Nashville).

a. Primary Metals

Among the nonferrous primary metals produced in the PSAs, aluminum is indisputably predominant. Its production in 1976 constituted approximately 80 percent of total nonferrous primary metals production. Production of other primary metals, such as copper, zinc, lead and other minor nonferrous primary metals, was negligible (Table 9).

The major production areas of aluminum are concentrated in the central ORB. They are BEA 48 (Chattanooga), BEA 49 (Nashville), BEA 50 (Knoxville), BEA 52 (Huntington), BEA 55 (Evansville), and, BEA 66 (Pittsburgh).

Of these six major production areas, BEA 55 is by far the largest (36.3 percent of total primary aluminum production). BEAs 50 and 66 each accounted for approximately 19.5 percent of total aluminum production, while BEAs 48, 49 and 52 each accounted for approximately 8 percent of total production.

b. Mill and Foundry Products

The major production areas of aluminum mill and foundry products coincide with those of primary aluminum metal. The six primary aluminum producing areas (BEAs 48, 49, 50, 52, 55 and 66) accounted for over 93 percent of the total aluminum semi-fabricated product production in the area served by the ORS in 1976. BEA 62 (Cincinnati) accounted for approximately 7 percent of total aluminum mill and foundry products produced in the PSAs.

Copper mill and foundry products produced in the PSAs were insignificant. They accounted only for approximately 9 percent of the total mill and foundry products. It should be pointed out that three of the seven BEAs accounted for all copper mill and foundry products in the PSAs. These three major production areas and their individual shares of total production were as follows: BEA 66, 55.0 percent; BEA 48, 18.6 percent; and BEA 49, 9.7 percent.

A-2. Secondary Production Areas (SPAs)

Inbound traffic constituted the bulk of the total nonferrous metal waterborne commerce in the ORS. Of the 246.9 thousand tons of Group XIII traffic in the ORS in 1976, 215.0 thousand tons were from origins outside the System.

Table 9. Ohio River Basin: Production of Nonferrous Metals and Alloys,[a] by BEAs or BEA Segments[b] and by Commodities, Estimated 1976

(Thousands of tons)

BEA or BEA segment	Aluminum: Primary metal	Aluminum: Mill and foundry products	Copper: Primary metal	Copper: Mill and foundry products	Primary lead	Slab zinc	Other primary nonferrous metals
Primary Study Areas	1,500.6	825.9	45.8	79.7	35.3	191.4	92.5
BEA 48: Chattanooga, TN	123.3	41.2	45.8	14.8	--	--	--
BEA 49: Nashville, TN	123.3	64.3	--	14.8	--	--	12.9
BEA 50: Knoxville, TN	293.3	207.5	--	--	--	--	--
BEA 52: Huntington, WV	123.3	207.5	--	--	--	--	--
BEA 55: Evansville, TN	544.1	172.9	--	--	--	--	--
BEA 62: Cincinnati, OH	--	57.6	--	6.3	35.3	--	--
BEA 66: Pittsburgh, PA	293.3	74.9	--	43.8	--	191.4	79.6

Note: Production by BEA segments of each nonferrous metal was calculated from its total U.S. production, based on the employment distribution ratios obtained by dividing the number of employees of a particular metal industry in each BEA segment by the total U.S. employment of that industry.

a. Includes the primary metals of aluminum, copper, lead, zinc, nickel, titanium, magnesium, tin, antimony, manganese, and cadmium, and primary products of aluminum, copper and molybdenum.

b. BEA segments are defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, 1978; U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1976; American Metal Market, Metal Statistics, 1978; The Aluminum Association, Aluminum Statistical Review, 1977; U.S. Department of Commerce, Bureau of the Census, County Business Patterns, 1976 ed.

The major SPA for primary aluminum in 1976 was BEA 140 (Beaumont). There were also several shipments of imported anode blocks from BEA 138 (New Orleans). Waterborne shipments of primary aluminum originating in Point Comfort, Texas (in BEA 141), also were reported in 1976.

The major SPA for slab zinc in 1976 was BEA 143 (Corpus Christi). Several waterborne shipments of imported zinc concentrate, originating in New Orleans, were also received in the Ohio River Basin.

B. Production Characteristics

Production characteristics of nonferrous metal products vary from metal to metal. However, it can be said that the primary nonferrous metal industry is basically a capital intensive industry and is controlled by several large, vertically integrated firms. The primary nonferrous metal industry, as a whole, has been plagued by several problems, such as the availability of capital, air and water pollution control, and uncertain demand. In addition, raw materials, minerals and ores, required for the production of primary metals, have availabilities which range from abundant to scarce.

For a variety of reasons, only the production characteristics of aluminum products (primary metal as well as mill and foundry products) are important for this study: (1) aluminum products constitute close to 85 percent of total nonferrous metal product production in the PSAs; (2) among all of the nonferrous metals, aluminum holds the most important position in the nonferrous waterborne commerce; and (3) demand for aluminum products is expected to increase in the future faster than the demand for other nonferrous metal products.

Because industry structure, technological characteristics and other production characteristics are markedly different between primary aluminum metal and aluminum mill and foundry products, the production characteristics of primary aluminum and those of mill and foundry products are discussed separately.

B-1. Primary Aluminum Metal

Currently 12 domestic firms are engaged in the production of primary aluminum metal. Three firms (Alcoa, Reynolds and Kaiser) alone accounted for 65 percent of total domestic primary aluminum

capacity in 1976.[1] Total primary aluminum capacity of the United States that year was approximately 5,193 thousand tons, about one-third of which was located in the area served by the ORS.[2]

a. Economic Characteristics

Aluminum is a capital-intensive industry. Thus, the economies of scale for the industry strongly favor the concentration of production by a few large producers.

On the demand side, the United States has long been the largest aluminum consumer of the world. But, because of a lack of domestic raw materials, production has not been able to keep up with demand. As a result, the United States has been increasingly reliant on imports to meet demand and is expected to remain so in the future. Consequently, demand will not pose any constraint on future production.

b. Technological Characteristics

Despite all of the technological improvements since aluminum first became available in commercial quantities (almost 90 years ago), the basic production process has remained relatively unchanged.[3] Primary aluminum metal is reduced from alumina in a molten bath of natural or synthetic cyrolite through a process of electrolysis. The cyrolite serves as a solvent for the alumina.

The most common smeltering processes currently employed in the production of primary aluminum metal are the prebaked anode system and the Soderberg method. The major differences between these two methods are that the prebaked anode system is more efficient, while the Soderberg system requires less labor.

Regardless of the process employed for the reduction of alumina to aluminum, large amounts of electricity are required. Because of electrical resistance, voltage efficiency is only 40 percent. The overall energy efficiency achieved by the industry is approximately 35 percent.[4]

---

1. U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles: Aluminum; MCP 14 (Washington, D.C.: Bureau of Mines, 1978), p. 13.
2. Ibid., p. 5, Figure 1.
3. Ibid., p. 1.
4. Ibid., p. 14.

c. Environmental Considerations

Production of primary aluminum metal does not create serious pollution in the environment. The only source of pollution is the toxic fumes evolved from the cell during the process of electrolysis. To prevent atmospheric pollution, several methods have been developed to collect the fumes and to recycle useful chemicals contained in them.

B-2. Mill and Foundry Products

Currently, there are several hundred independent fabricators throughout the United States who process primary aluminum metal into mill and foundry products, such as sheet, plate, wire, casting, etc. Some of the larger domestic primary aluminum producers are also engaged in manufacturing these semi-fabricated products. The vast majority of fabricators are located in the Northeast, East North Central and East South Central regions of the United States.[1]

While domestic production of primary aluminum metal has trailed behind domestic demand, production of aluminum semi-fabricated products has exceeded demand. Exports of mill products in the last decade have been increasing. Net exports of aluminum mill products in 1977 were 182 thousand short tons.[2]

Although the aluminum fabricating industry is also a capital-intensive industry, the fact that several hundred large and small establishments co-exist in the industry indicates that equal efficiency can be achieved at different scales of production.

As in the case of primary aluminum metal production, the negative impact of fabricating activities on the environment is believed to be minimal. Wastes resulting from the process are recycled by the manufacturers.

C. Production Inputs

In addition to alumina, large quantities of several other raw materials are required for the production of metallic aluminum.

---

1. The Aluminum Association, Aluminum Statistical Review, 1977 ed., (Washington, D.C.: The Aluminum Association, n.d.), pp. 37-38.
2. Ibid., p. 69.

The inputs vital to production are, primarily, electricity and labor. Only production inputs of primary aluminum metal have been examined in detail. Production inputs for mill and foundry products are basically primary aluminum metal and labor. The labor requirement of mills and foundries varies widely, from less than 20 employees to several thousand.

C-1. Mineral and Ore

The major raw material required for the production of primary aluminum, alumina, is extracted from bauxite. The United States has a very small bauxite reserve, and the only domestic bauxite mining is in Arkansas, Alabama and Georgia. The primary sources of alumina have been countries in the Caribbean and in South America. In recent years, research has been aimed toward the development of recovery methods for domestic sources of aluminum such as clay, shale and other aluminum bearing mineral deposits.

Another major raw material used in the production of aluminum is cryolite, which is required to dissolve the alumina. It permits electric currents to pass through the fused solution, which then separates the metal. In recent years, synthetic cryolite has taken the place of natural cryolite, since there has been a gradual exhaustion of natural cryolite. The third major raw material required in the reduction process is petroleum coke. This material is consumed at the rate of approximately one-half ton for every ton of aluminum metal.

C-2. Electricity

One of the major problems facing the primary aluminum industry, besides the limited domestic supply of bauxite, is the availability of large amounts of continuous electricity. During the reduction process, large amounts of electricity are required. It is estimated that about ten kilowatt hours of electricity are required to produce one pound of aluminum, an amount sufficient to keep a 40-watt light burning constantly for more than ten days.[1] Therefore, primary aluminum plants frequently locate near sources of hydroelectric power in order to secure a sufficient supply of electricity.

Recently, Alcoa has developed a new process which is reported to be able to reduce electricity consumption by 30 percent. The

---

1. Charles C. Carr, Alcoa-An American Enterprise (New York: Rinehard & Company, Inc., 1952), p. 85.

impact of this process on future production is difficult to assess at this stage. Production of primary aluminum, in any case, is not likely to be impeded by increased costs of electricity due to the strong demand for the material However, the proportion of U S demand met by domestic production is expected to decrease in the future.

C-3 Labor

Primary aluminum is a capital intensive industry that does not employ labor to the extent of other metal industries The number of aluminum workers is small in comparison to both the capital employed and the electricity consumed.[1] The aluminum industry labor force is primarily composed of engineers, technicians and other skilled workers It is estimated that approximately 8 to 20 person-hours of labor (including supervision), depending on the reduction method employed, are required for the production of one ton of primary aluminum metal[2]

D. Existing Production Levels

The national production level of nonferrous metal products showed a general growth trend from 1969 to 1973 (Table 10) However, production started to decline in 1974, and 1975 registered the lowest output of the last decade. Output dropped from a high of 18,823 thousand tons in 1973 to 14,084 thousand tons in 1975, a decrease of more than 25 percent. The sharp decline of production in 1974 and 1975 directly reflected the adverse economic conditions in the economy following the oil embargo late in 1973 The recession induced by the oil embargo caused the demand for all nonferrous metals to decline. Production began to improve in 1976, and by 1978 most of the major nonferrous metals had regained their 1973 production levels.

It should be pointed out that while most of the nonferrous metals experienced a general growth trend from 1969 to 1976, primary zinc registered a constant decline from 1,149 thousand tons in 1969 to 536 thousand tons in 1976. This constitutes a decrease in production of more than 50 percent in eight years The deterioration of the zinc industry was partially a result of rising production costs, created by environmental and health protection measures, and partially a result of a lack of capital for capacity

---

1. U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profile: Aluminum; MCP 14 (Washington, D C Bureau of Mines, 1978), p. 23.
2. Ibid., p. 23

Table 10. United States: Production of Nonferrous Metals and Alloys, Estimated 1969-76

(Thousands of tons)

Commodity	1969	1970	1971	1972	1973	1974	1975	1976
Total	16,427	15,801	15,709	17,235	18,823	18,175	14,084	16,458
Aluminum:								
Primary metal	3,793	3,976	3,925	4,122	4,529	4,903	3,879	4,251
Mill and foundry products[a]	4,714	4,488	4,777	5,548	6,549	6,475	4,535	5,916
Copper:								
Primary metal[b]	1,985	2,004	1,787	2,027	1,997	1,741	1,551	1,698
Mill and foundry products[c]	3,274	2,821	2,910	3,241	3,597	3,100	2,324	2,757
Primary Lead	639	667	650	680	675	673	636	653
Primary Zinc	1,149	961	840	765	687	590	446	536
Others[d]	873	884	820	852	789	693	713	647

a. Includes plates, sheets, foils, forgings, extruded shapes, tubings, rods, bars, wires, powder and castings; estimated from shipments.

b. Refined.

c. Includes wires, castings, granular powder and brass mill products.

d. Includes antimony, beryllium, cadmium, chromium, magnesium, manganese, molybdenum, nickel, tin and titanium. 1974-76 production of magnesium derived from value of shipments.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, 1972-78; U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1976; American Metal Market, Metal Statistics, 1971-78; The Aluminum Association, Aluminum Statistical Review, 1977 ed.

expansion.[1] If current industry expansion plans can be realized, this situation will improve in the future.[2]

Regional production data, at the BEA level, are not available. Estimates of production in the seven PSAs have depended heavily on BEA employment data. In the process of estimating regional (BEA) production, an assumption has been made that industry employment distribution is a reasonable indicator of production distribution for the various primary metal industries.

An alternative method used the plant capacity data to estimate levels of output. However, capacity utilization ratios of individual plants as well as the actual capacities of some plants (especially those producing semi-fabricated products) are not available. Estimates of the production of some metals were obtained from this method and were used to compare with those obtained from the industry employment distribution method. As was expected, discrepancies existed between the results of these two methods. The magnitudes of discrepancy varied from metal to metal. On the average, production levels obtained from the employment data seem to be slightly higher than those from capacity data. Results generated from employment data were adopted for this study since capacity data were not available for plants producing more than half of the products in this commodity group.

From Table 11, it can be seen that the production trends of the PSAs reflect that of the United States as a whole. Production increased from 1969 to 1973 and started to decline in 1974. It reached its lowest level in 1975 and began to recover in 1976.

The share of U.S. nonferrous metal production attributable to the PSAs has been increasing rapidly from 11.1 percent in 1969 to 16.8 percent in 1976. This is a direct result of the rapidly growing aluminum industry in the PSAs. The regional share of U.S. total aluminum production (including mill and foundry products) was 22.9 percent in 1976.

E. Forecasting Procedures and Assumptions

The procedures for projecting future production of nonferrous metals and alloys are the same as those employed to

---

1. U.S. Department of Commerce, Domestic and International Business Administration, U.S. Industrial Outlook, 1977 ed. (Washington, D.C.: GPO, 1977), p. 83.
2. Ibid., p. 83.

Table 11. Ohio River Basin: Production of Nonferrous Metals and Alloys,[a] by BEAs or BEA Segments,[b] Estimated 1969-76

(Thousands of tons)

BEA or BEA segment		1969	1970	1971	1972	1973	1974	1975	1976
Primary Study Areas		1,827.8	1,801.7	1,772.1	1,883.5	2,049.2	2,594.7	2,215.1	2,771.2
BEA 48:	Chattanooga, TN	89.0	86.3	84.3	96.7	105.0	156.9	165.0	225.1
BEA 49:	Nashville, TN	145.6	146.8	147.0	159.4	176.0	208.4	177.7	215.3
BEA 50:	Knoxville, TN	242.8	254.5	251.2	263.8	289.9	548.7	422.6	500.8
BEA 52:	Huntington, WV	184.2	185.4	188.4	206.6	234.3	281.1	244.9	330.8
BEA 55:	Evansville, IN	463.2	471.8	468.2	503.2	549.1	649.6	569.8	717.0
BEA 62:	Cincinnati, OH	49.9	46.9	49.7	57.4	67.5	79.9	72.2	99.2
BEA 66:	Pittsburgh, PA	653.1	610.0	583.3	596.4	627.4	670.1	562.9	683.0

Note: Production by BEAs and BEA segments of each nonferrous metal was calculated from its total U.S. production, based on the employment distribution ratios obtained by dividing the number of employees of a particular metal industry in each BEA segment by the total U.S. employment of that industry.

a. Includes the primary metal of aluminum, copper, lead, zinc, nickel, titanium, magnesium, tin, antimony, manganese, and cadmium, and primary products of aluminum, copper, and molybdenum.

b. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: U.S. Department of Commerce, Bureau of Economic Analysis, Survey of Current Business, 1972-78; U.S. Department of Commerce, Bureau of the Census, Annual Survey of Manufactures, 1976; American Metal Market, Metal Statistics, 1971-78; The Aluminum Association, Aluminum Statistical Review, 1977 ed.; U.S. Department of Commerce, Bureau of the Census, County Business Patterns, 1973, 1974, 1976 eds.

project future demand. Future U.S. production levels of the various nonferrous metals and alloys were used to estimate future production levels for each of the seven PSAs of the ORB.

Projections of the U.S. Bureau of Mines are used for future national production estimates. The projected growth rates for the various nonferrous metals were then compared with the projected national growth rate for earnings in the primary metal industry. This relationship was then used to determine production growth in the BEAs. Projections of earnings in the primary metal industry were available from the U.S. Department of Commerce.

E-1. Forecasting Methodology of Bureau of Mines

The individual projections for nonferrous metal production are results of regression analyses based on the historical trend of production or derived from the historical relationship between domestic production and demand as well as the judgments of commodity specialists of the Bureau of Mines. For instance, primary aluminum production was estimated to be 85 and 80 percent of domestic demand in 1985 and 2000, respectively. The projections were based on the relationship between domestic production and demand over the past nine years and on the predicted future energy outlook for the United States. On the other hand, projection of copper production was estimated primarily from a 20-year historical trend which was then adjusted in accordance to the projection of future domestic mine production.

Apart from the fact that the projections of the Bureau of Mines are the only available long-range projections (up to year 2000) for tonnage, there are two other reasons for adopting Bureau of Mines projections in this study: (1) they are probably the most reasonable long-range projections, and (2) they cover almost all of the nonferrous metals.

E-2. Assumptions

Several assumptions were made in projecting future production levels. These assumptions can be summarized as follows: (1) the economy will not suffer any drastic disruptions during the forecasting period; (2) growth will continue in the period 2000-2040, but at a less rapid rate than projected for the period 1976-2000.

F. Probable Future Production Levels

Future U.S. production of nonferrous metals and alloys for selected years during the period 1980 to 2040 is presented in Table 12. The aggregate production level of nonferrous metals and alloys is projected to increase from the 1974-76 average of 16,238 thousand tons to 42,338 thousand tons in 2000, an average annual growth rate of 3.9 percent.

The average annual growth rate is projected to decline after year 2000 from 1.9 to 2.5 percent between the period of 2000 to 2040. The production level of nonferrous metals and alloys is estimated to reach 89,715 thousand tons in 2040.

Of all nonferrous metals, primary aluminum metal and the aluminum mill and foundry products are projected to experience the highest growth rates (4.4 percent and 4.7 percent, respectively, in the period 1976-2000). Production of zinc is projected to increase at a much slower pace than that of other nonferrous metals.

As shown in Table 13, production of nonferrous metals in the PSAs is expected to increase at a much higher rate than in the United States as a whole. It is estimated that production in the PSAs will increase from the 1976 level of 2,771.2 thousand tons, at an average annual growth rate of 5.5 percent, to 9,909.1 thousand tons in 2000. The rate of increase is expected to slow down to 2.4 percent from 2000 to 2040, and production is projected to reach 25,236.1 thousand tons in 2040.

Because of higher growth rates, the PSA share of total U.S. nonferrous metal product production is expected to increase. While the PSA share of U.S. nonferrous metal production was 16.8 percent in 1976, it is projected that it will increase to 28.1 percent in 2040. The major explanation for this trend is that aluminum has been the fastest growing nonferrous metal in the past decade, and the bulk (84.0 percent) of nonferrous metal production produced in the PSAs in 1976 consisted of aluminum products (including mill and foundry products). Furthermore, it is estimated that approximately one-third of the primary aluminum production capacity is currently located in the area served by the ORS.

Table 12. United States: Production of Nonferrous Metals and Alloys, Estimated Average 1974-76 and Projected 1980-2040

(Thousands of tons unless otherwise specified)

Commodity	Estimated average 1974-76	Projected 1980	1990	2000	2020	2040	Average annual percentage change 1974-76—2000	2000-2040
Total	16,238	20,475	31,109	42,338	69,592	89,715	3.9	1.9
Aluminum:								
Primary metal	4,344	5,636	9,147	12,706	21,648	28,307	4.4	2.0
Mill and foundry products[a]	5,642	7,843	12,728	17,681	31,320	41,770	4.7	2.2
Copper:								
Primary metal[b]	1,663	1,878	2,509	3,323	4,748	5,680	2.8	1.3
Mill and foundry products[c]	2,727	3,049	4,074	5,395	7,558	8,952	2.8	1.3
Primary lead	654	735	912	1,062	1,348	1,519	2.0	0.9
Primary zinc	524	579	670	743	889	973	1.4	0.7
Others[d]	684	755	1,069	1,428	2.081	2,514	3.0	1.4

Note: Projections for production from 1980 to 2000 calculated from the projections (for 1985 and 2000) made by Bureau of Mines. Projected production for 1980 and 1990 obtained from linear extrapolations based on 1976, 1985 and 2000 estimates. Production from 2000 to 2020 assumed to increase equal to three-fifths of the average annual percentage increase in production between 1974-76 average and 2000. Production from 2020 to 2040 projected to increase at an average annual rate equal to half the rate projected for 2000 to 2020. Mill and foundry products assumed to increase at the same rates as primary metals. Projection of primary zinc production (1985 and 2000) from unpublished information provided by Bureau of Mines. For other minor nonferrous metals such as antimony, berylliums, cadmium, chromium, magnesium, manganese, molybdenum, nickel, tin and titanium, projections based on projected demand for minerals and ores.

a. Includes plates, sheets, foils, forgings, extruded shapes, tubings, rods, wires, bars, powder and castings.
b. Refined.
c. Includes wire mill, foundry casting, granular powder and brass mill products.
d. Includes antimony, beryllium, cadmium, chromium, magnesium, manganese, molybdenum, nickel, tin and titanium.

Sources: Production figures of 1974-76 average from Table 10. Projections from U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles, 1977-78 eds.; U.S. Department of the Interior, Bureau of Mines, Mineral Trends and Forecasts, 1976 ed.; and from unpublished information provided by the Bureau of Mines.

Table 13. Ohio River Basin: Production of Nonferrous Metals and Alloys, by BEAs or BEA Segments,[a] Estimated 1976 and Projected 1980-2040

(Thousands of tons unless otherwise specified)

BEA or BEA segment	Estimated	Projected					Average annual percentage change	
	1976	1980	1990	2000	2020	2040	1976-2000	2000-2040
Primary Study Areas	2,771.2	3,610.4	6,692.4	9,909.1	18,407.2	25,236.1	5.5	2.4
BEA 48: Chattanooga, TN	225.1	263.8	517.0	768.2	1,420.1	1,935.4	5.2	2.3
BEA 49: Nashville, TN	215.3	300.7	677.4	1,061.1	2,091.1	2,946.8	6.8	2.6
BEA 50: Knoxville, TN	500.8	646.0	1,122.4	1,597.1	2,807.1	3,728.9	5.0	2.1
BEA 52: Huntington, WV	300.8	388.7	649.6	910.1	1,574.9	2,075.7	4.7	2.1
BEA 55: Evansville, IN	717.0	1,117.8	2,626.9	4,202.1	8,426.2	11,968.2	7.6	2.7
BEA 62: Cincinnati, OH	99.2	119.0	172.5	228.7	371.1	473.9	3.5	1.8
BEA 66: Pittsburgh, PA	683.0	774.4	926.6	1,141.8	1,716.7	2,107.2	2.2	1.5

Note: Figures of 1976 production of the BEAs and BEA segments were used to calculate the future production of the BEA segments. Growth rates for the period 1976-2020 for each of the BEA segments were calculated by comparing the projected growth rates of the primary metal industry (measured by real earnings) of the BEAs with the projected growth rates of the production of nonferrous metals and alloys of the United States. Production by BEA during the period 2020-2040 was projected to increase at an average annual rate equal to half the rate projected for the period 2000-2020.

a. BEA segments defined as counties which are ultimate origins or destinations of waterborne movements.

Source: Production figures of 1976 from Table 11. Projections from U.S. Department of the Interior, Bureau of Mines, Mineral Commodity Profiles, 1977-78 eds.; U.S. Department of the Interior, Bureau of Mines, Mineral Trends and Forecasts, 1976 ed.; and U.S. Water Resources Council, OBERS Projections, 1972 ed., Vol. II.

IV. TRANSPORTATION CHARACTERISTICS

At the national level, water is an insignificant mode of transportation for primary nonferrous metal products. Of all primary nonferrous metal product shipments in 1972, water accounted for only 0.7 percent, while rail and motor carrier accounted for 45.9 percent and 53.1 percent, respectively.[1] Even within the PSAs, water accounts for a small portion of the traffic. This is not expected to change during the projection period.

A. Existing and Historical Modal Split

Information on the 1976 modal split of water, rail and truck transport of nonferrous metal products in the area served by the ORS is available in Table 14. This table provides total net shipments of nonferrous metal products by water, rail and truck transport as well as the inbound, outbound and local traffic by water and rail. However, it should be noted that the lack of information on inbound, outbound and local truck traffic makes a complete comparison of water, rail and truck traffic impossible. Nevertheless, the table provides a useful picture of the modal split for nonferrous metals and alloys in the PSAs in 1976.

The table indicates that, in 1976, the study area registered net shipments of 1,306.3 thousand tons of nonferrous metal products. The total outbound traffic exceeded the total inbound traffic of nonferrous metal products by that net amount. While truck and rail registered net shipments of 420.5 and 1,089.7 thousand tons, respectively, inbound water receipts exceeded outbound shipments by 203.9 thousand tons. One explanation for

---

1. U.S. Department of Commerce, Bureau of the Census, Census of Transportation - Primary Metals Products; 1972 ed. (Washington, D.C.: GPO, 1976).

PRECEDING PAGE BLANK-NOT FILMED

Table 14. Ohio River Basin: Production, Consumption, and Shipments by Mode of Transportation Of Nonferrous Metals and Alloys, by BEAs or BEA Segments,[a] 1976

(Thousands of tons)

				Shipments (receipts)									
				Water				Rail					
BEA or BEA segment	Pro-duction	Consump-tion	Total net	Net	In-bound	Out-bound	Local	Net	In-bound	Out-bound	Local	[illegible]	
Primary Study Areas	2,771.2	1,464.9	1,306.3	(203.9)	215.0[b]	11.1[b]	20.8[b]	1,089.7	457.0[b]	1,546.7[b]	138.0[b]	[illegible]	
BEA 48: Chattanooga, TN	225.1	109.8	115.3	(21.2)	21.2	--	--	2.6	4.5	7.1	6.6	[illegible]	
BEA 49: Nashville, TN	215.3	188.4	26.9	(55.6)	65.6	10.0	--	(14.1)	27.7	13.6	--	[illegible]	
BEA 50: Knoxville, TN	500.8	29.6	471.2	--	--	--	--	160.7	41.4	202.1	--	[illegible]	
BEA 52: Huntington, WV	330.8	229.2	101.6	(53.6)	53.6	--	--	9.9	98.0	107.9	--	[illegible]	
BEA 55: Evansville, IN	717.0	230.1	486.9	(21.4)	23.6	2.2	--	185.3	316.6	501.9	12.5	[illegible]	
BEA 62: Cincinnati, OH	99.2	199.0	(99.8)	(27.8)	27.8	--	--	29.0	16.2	45.2	6.6	[illegible]	
BEA 66: Pittsburgh, PA	683.0	478.8	204.2	(24.3)	31.0	6.7	13.0	716.3	99.0	815.3	28.1	[illegible]	

Note: Gross and net waterborne and rail shipments (receipts) were determined for 1976 from U.S. Corps of Engineers waterborne commerce data and Interstate Commerce Commission railroad waybill data. Total net shipments (receipts) were determined by subtracting consumption from production. Net truck shipments (receipts) were determined by subtracting net waterborne and rail shipments (receipts) from total net shipments (receipts).

a. BEA segments defined as counties which are ultimate origins and destinations of waterborne movements.

b. Total Primary Study Areas shipments equal inbound, outbound, and local shipments for the Basin as a unit and do not equal the sum of shipments reported for each of the BEAs and BEA segments.

Source: Estimated production and consumption from Tables 6 and 11. Water and rail shipments (receipts) compiled by RRNA from Waterborne Commerce by Port Equivalents, 1976, and ICC Railroad Waybill Sample, 1976, supplied by the U.S. Army Corps of Engineers.

this phenomenon might be that the composition of nonferrous metal traffic using water is different from that which uses rail and truck, such that primary metals are transported by water while semi-fabricated products, as well as primary metals, are shipped by rail and truck.

The table further reveals that water transport constituted a very small portion of the total nonferrous metal product traffic in the area served by the ORS. For instance, in 1976, waterborne shipments accounted for only 3.7 percent of the total net nonferrous metal product shipments in the PSAs.

B. Intermodal Characteristics

The only intermodal transfers for Group XIII are transfers between plants and waterside barge facilities by motor carriers. No intermodal transfers between rail and water were reported.

For all outbound waterborne shipments originating in the ORS, the originating plants are located near the waterway. When shipments are made, motor carriers carry the products from plant to waterside. Similarly, the receiving plants are located within a few miles of the waterway.

C. Factors Affecting Modal Choice

There are several factors which are important in considering the most economical mode for the transport of nonferrous metals. Differences in the rates for truck, rail and water, as well as distances between origins and destinations, are important factors in determining the modal choice.[1] The fact that virtually all of the waterborne nonferrous metal traffic is composed of primary metals indicates that the transportation requirements of the primary metals and those of the semi-fabricated products are different.

Two of the reasons that make water an attractive choice for primary metals can be briefly summarized as follows: (1) primary metals are heavy, bulky and can be handled without special care; (2) the destinations of primary metals are usually confined to a

---

1. Freight rates vary not only with the mode of transport but also with the type of product shipped, specific conditions of the run, distance shipped, competitive situations and other factors. It is, therefore, difficult to make exact comparisons.

relatively small number of mills and foundries, thus modal flexibility is not as important as it is for other commodities and products.

The fact that the users of mill and foundry products are scattered widely makes water transport less attractive than truck and rail for shipping these products. Furthermore, time considerations also play important roles -- particularly given the relatively high value of these products and costs of investment held in inventory.

Rate differentials constitute only one of the factors that govern modal choice. The demand for water transport of nonferrous metal products is largely price-inelastic. A small change in the barge rates will not significantly alter the existing modal split. The impact of a large change cannot be determined without extensive research.

D. Forecasting Procedures and Assumptions

Forecasts of future shipments and receipts of nonferrous metal products are based primarily on projections of production and consumption of these commodities. Initial projections of waterborne commerce were developed using preliminary information provided by the Corps of Engineers. These initial projections were based on the 1976 modal split by BEA and BEA segment. Projections of total net shipments/receipts of each of the seven BEA segments were made by comparing the projected future production and consumption of nonferrous metal products of these BEAs. The total net shipments/receipts were then distributed to rail, truck and water based on existing patterns. Gross water movements were assumed to maintain the same relationship to net water movements in the future as in the past.

These projections of waterborne shipments and receipts were distributed to BEA links using historical distribution of shipments data among BEA receivers. These projections were adjusted for projected changes in BEA shipments and receipts from specific knowledge acquired by commodity specialists during the course of this study.

As more complete information was made available by the Corps of Engineers, the initial projections of BEA-to-BEA waterborne traffic were adjusted.[1]

Assumptions

For these projections of Group XIII shipments, several assumptions are made: (1) existing and historical modal split remains unchanged during the forecasting period; (2) the relative rates (transport charges) of the different transport modes remain stable; and (3) no major improvements are made in the waterways.

E. Probable Future Modal Split

Unless there is a significant change in relative rates among water, rail and truck resulting from future technological improvements or economic costs, no significant change is expected in the existing modal split of the nonferrous metal products. Throughout the period, from 1976 to 2040, water movements of nonferrous metal products will be relatively insignificant. The composition of the future waterborne nonferrous metal traffic is unlikely to change.

Although the production of nonferrous metal products in the PSAs is projected to exceed consumption, the volume of inbound waterborne movements of these products will likely remain larger than outbound traffic movements and, in fact, the difference is expected to increase (Table 15). As for rail and truck, the level of outbound traffic is expected to continue to exceed that of inbound traffic.

F. Probable Future Waterway Traffic Flows

The total volume of nonferrous waterborne shipments in the ORS is projected to increase at an average annual rate of 4.0 percent between 1976 and 2000, from 246.9 thousand tons in 1976 to 633.1 thousand tons in 2000. The rate of increase, however, is expected to level off in the more distant future. The average annual rate of increase from 2000 to 2040 is projected to be 2.3 percent. The total volume of waterborne nonferrous metal products in the ORS is projected to reach 1,567.8 thousand tons in 2040.

BEA-to-BEA waterborne traffic projections are presented in Table 16. Projected growth indices for selected years between 1976 and 2040 are presented in Table 17.

---

1. A description of the manner in which the initial projections were adjusted is contained in the Methodology Report.

Table 15. Ohio River Basin: Production, Consumption and Shipments by Mode of Transportation of Nonferrous Metals and Alloys, Nec., Estimated 1976 and Projected 1980-2040, Selected Years

(Thousands of tons unless otherwise specified)

	Estimated	Projected					Average annual percentage change	
	1976	1980	1990	2000	2020	2040	1976-2000	2000-2040
Production	2,771.2	3,610.4	6,692.4	9,909.1	18,407.2	25,236.1	5.5	2.4
Consumption	1,464.9	1,814.0	2,681.2	3,575.9	6,050.3	7,893.2	3.8	2.0
Net shipments (receipts)	1,306.3	1,796.4	4,011.2	6,333.2	12,356.9	17,342.9	6.8	2.6
Net waterborne	(203.9)	(237.2)	(344.7)	(451.2)	(804.0)	(1,087.7)	3.4	2.2
Net rail	1,089.7	1,255.8	1,742.9	2,405.2	4,126.7	5,487.7	3.4	2.1
Net truck	420.5	777.8	2,613.0	4,379.2	9,034.2	12,942.9	10.3	2.8
Gross waterborne shipments:								
Outbound	11.1	20.7	37.3	58.7	112.6	167.7	7.2	2.7
Inbound	215.0	257.9	382.0	509.9	916.6	1,255.4	3.7	2.3
Local	20.8	30.0	48.9	64.5	109.5	144.7	4.8	2.0
Total	246.9	308.6	468.2	633.1	1,138.7	1,567.8	4.0	2.3

Note: Projected net shipments (receipts) determined by subtracting projected consumption from projected production. Initial projections of waterborne shipments and receipts were based on preliminary information provided by the Corps of Engineers. Projected modal split for the ORB was estimated from projections of modal split for each BEA and BEA segment. For most BEAs, projected modal split would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. Gross waterborne shipments for each BEA (inbound, outbound, local) were projected by assuming that the relationship between gross and net waterborne shipments in 1976 would remain constant in the future except when data, analyses and conversations with industrial authorities indicated otherwise. For BEAs 48, 49, 52, 55, and 66, waterborne receipts were assumed to increase at the same rate as consumption; waterborne shipments were assumed to increase at the same rate as production. As more complete information regarding 1976 waterborne traffic was made available, BEA-to-BEA traffic projections were revised, and projected to increase/decrease at the same rates as projected earlier. Net truck and net rail shipments by BEA and BEA segment were assumed to have the same relationship to one another that existed in 1976.

Source: Tables 8, 13 and 14; Waterborne Commerce by Port Equivalents, 1969-76, supplied by the U.S. Army Corps of Engineers.

Table 16. Ohio River System: BEA-to-BEA Waterborne Traffic of Nonferrous Metals and Alloys, Nec., Actual 1976 and Projected 1980-2040, Selected Years

ORIGIN BEA	DESTINATION BEA	COMMODITY GROUP	HUNDREDS OF TONS 1976	1980	1990	2000	2020	2040
049	066	13	22	19	94	122	230	362
049	140	13	78	118	227	375	745	1537
050	066	13	0	64	111	160	280	492
050	079	13	0	44	78	112	197	346
055	066	13	11	14	20	26	43	70
055	138	13	11	17	40	65	129	259
066	062	13	45	58	96	135	251	459
066	066	13	130	145	168	202	291	414
066	141	13	22	28	28	35	55	84
077	048	13	11	14	24	32	57	101
114	048	13	156	159	273	378	663	1199
114	052	13	56	66	75	96	147	236
114	055	13	33	171	260	351	609	1058
114	066	13	33	38	57	73	126	163
133	049	13	33	42	71	101	185	339
138	048	13	45	95	141	195	349	595
138	049	13	33	46	76	108	198	363
138	050	13	0	5	9	14	24	42
138	052	13	480	564	660	755	1490	2322
138	055	13	170	22	33	44	77	133
138	066	13	50	56	73	95	151	271
140	049	13	590	756	1268	1798	3299	6051
140	066	13	11	12	17	21	34	53
141	055	13	33	41	63	86	149	258
141	066	13	10	11	15	19	30	48
143	062	13	200	248	383	524	927	1636
143	066	13	140	156	212	269	429	684
144	062	13	33	36	45	51	66	84
144	066	13	33	41	65	89	156	276
		TOTAL	2469	3086	4632	6331	11387	19955

Source: Robert R. Nathan Associates, Inc.

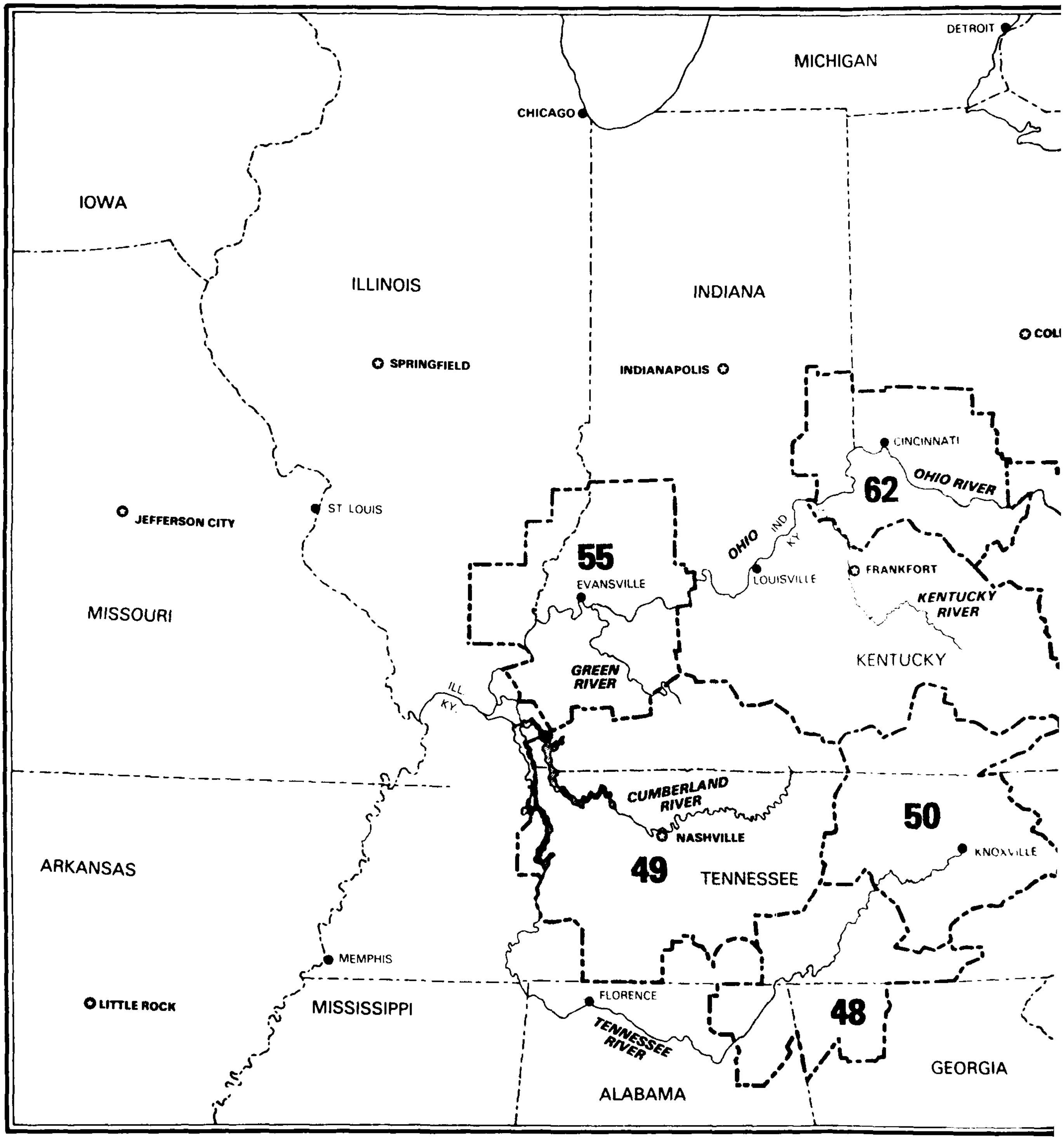
Table 17. Ohio River System: Growth Rates
of Nonferrous Metals and Alloys Waterborne Commerce,
BEA to BEA,
Projected 1976-2040,
Selected Years

BEA Pair[a]	Group No.	Index Value[b]	Year[c] 1976	1980	1990	2000	2020	2040
049066	13	22	1000	867	4267	5533	10467	13467
049140	13	78	1000	1507	2915	4803	9549	14627
050066	13	64	0	1000	1734	2500	4375	6032
050079	13	44	0	1000	1773	2545	4477	6171
055066	13	11	1000	1296	1810	2373	3886	5140
055138	13	11	1000	1565	3674	5870	11761	17663
066062	13	45	1000	1290	2129	3000	5581	7888
066066	13	130	1000	1114	1289	1554	2237	2713
066141	13	22	1000	1250	1250	1583	2500	3167
077048	13	11	1000	1286	2143	2929	5143	7143
114048	13	156	1000	1022	1748	2424	4252	5968
114052	13	56	1000	1175	1333	1714	2619	3421
114055	13	33	1000	5185	7889	10630	18444	25259
114066	13	33	1000	1138	1724	2207	3828	4690
133049	13	33	1000	1286	2143	3071	5607	7947
138048	13	45	1000	2122	3143	4327	7755	10490
138049	13	33	1000	1379	2310	3276	6000	8500
138050	13	5	0	1000	1800	2800	4800	6600
138052	13	480	1000	1175	1376	1572	3105	3972
138055	13	170	1000	129	194	258	452	619
138066	13	50	1000	1125	1458	1896	3021	4219
140049	13	590	1000	1282	2149	3047	5591	7924
140066	13	11	1000	1083	1500	1917	3083	3958
141055	13	33	1000	1257	1914	2600	4514	6172
141066	13	10	1000	1125	1500	1917	3042	3938
143062	13	200	1000	1240	1917	2620	4636	6409
143066	13	140	1000	1115	1513	1923	3064	3975
144062	13	33	1000	1091	1364	1545	2000	2273
144066	13	33	1000	1249	1955	2685	4733	6555

a. The first three digits include the BEA of origin; the last three digits indicate the BEA of destination.
b. Hundreds of tons.
c. Growth rates are reported such that 1000 equals the index value reported in the third column.
Source: Robert R. Nathan Associates, Inc.

V. APPENDIX

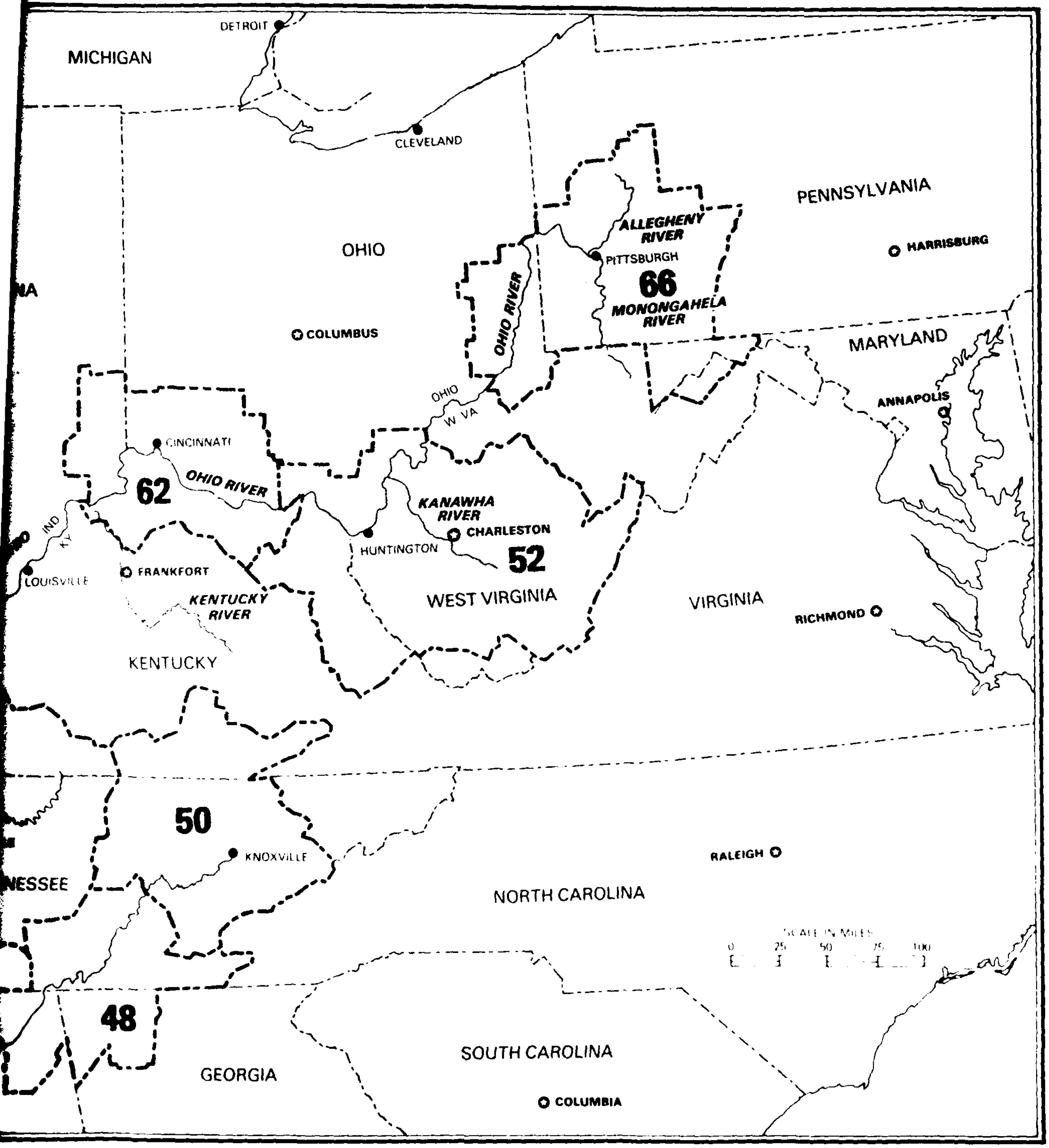
MAP A-1. OHIO RIVER BASIN: PRIMARY STUDY A
METALS AND ALLOYS (BEAS AND BEA S



SOURCE: Robert R. Nathan Associates, Inc.

Primary Study Area

VER BASIN: PRIMARY STUDY AREAS FOR NONFERROUS
AND ALLOYS (BEAS AND BEA SEGMENTS)



Primary Study Areas

12

Table A-1. Ohio River Basin: Primary Study Areas for Nonferrous Metals and Alloys (BEAs and BEA segments)

BEA 48 (segment): Chattanooga, TN
- DeKalb, AL
- Jackson, AL
- Catoosa, GA
- Chattooga, GA
- Dade, GA
- Walker, GA
- Whitfield, GA
- Bledsoe, TN
- Bradley, TN
- Grundy, TN
- Hamilton, TN
- Marion, TN
- McMinn, TN
- Meigs, TN
- Polk, TN
- Rhea, TN
- Sequatchie, TN

BEA 49 (segment): Nashville, TN
- Allen, KY
- Barren, KY
- Butler, KY
- Christian, KY
- Clinton, KY
- Cumberland, KY
- Edmonson, KY
- Logan, KY
- Metcalfe, KY
- Monroe, KY
- Simpson, KY
- Todd, KY
- Trigg, KY
- Warren, KY
- Benton, TN
- Cannon, TN
- Cheatham, TN
- Clay, TN
- Coffee, TN
- Davidson, TN
- DeKalb, TN
- Dickson, TN
- Giles, TN
- Hickman, TN
- Houston, TN
- Humphreys, TN
- Jackson, TN
- Lawrence, TN
- Lewis, TN
- Macon, TN
- Maury, TN
- Montgomery, TN
- Overton, TN
- Perry, TN
- Pickett, TN
- Putnam, TN
- Robertson, TN
- Rutherford, TN
- Smith, TN
- Stewart, TN
- Sumner, TN
- Trousdale, TN
- Van Buren, TN
- Warren, TN
- White, TN
- Williamson, TN
- Wilson, TN

BEA 50 (segment): Knoxville, TN
- Anderson, TN
- Blount, TN
- Campbell, TN
- Cumberland, TN
- Fentress, TN
- Grainger, TN
- Jefferson, TN
- Knox, TN
- Loudon, TN
- Monroe, TN
- Morgan, TN
- Roane, TN
- Scott, TN
- Sevier, TN
- Union, TN

BEA 52 (segment): Huntington, WV
- Boyd, KY
- Carter, KY
- Elliot, KY
- Greenup, KY
- Lawrence, KY
- Rowan, KY
- Gallia, OH
- Lawrence, OH
- Meigs, OH
- Scioto, OH
- Boone, WV
- Cabell, WV
- Clay, WV
- Fayette, WV
- Greenbrier, WV
- Jackson, WV
- Kanawha, WV
- Lincoln, WV
- Mason, WV
- Nicholas, WV
- Putnam, WV
- Raleigh, WV
- Roane, WV
- Sumners, WV
- Wayne, WV

BEA 55 (segment): Evansville, IN
- Caldwell, KY
- Crittenden, KY
- Daviess, KY
- Hancock, KY
- Henderson, KY
- Hopkins, KY
- McLean, KY
- Muhlenberg, KY
- Ohio, KY
- Union, KY
- Webster, KY
- Edwards, IL
- Gallatin, IL
- Hamilton, IL
- Saline, IL
- Wabash, IL
- White, IL
- DuBois, IN
- Gibson, IN
- Perry, IN
- Pike, IN
- Posey, IN
- Spencer, IN
- Vanderburgh, IN
- Warrick, IN

BEA 62 (segment): Cincinnati, OH
- Dearborn, IN
- Franklin, IN
- Ohio, IN
- Ripley, IN
- Switzerland, IN
- Boone, KY
- Bracken, KY
- Campbell, KY
- Carroll, KY
- Fleming, KY
- Gallatin, KY
- Grant, KY
- Kenton, KY
- Lewis, KY
- Mason, KY
- Owen, KY
- Pendleton, KY
- Robertson, KY
- Adams, OH
- Butler, OH
- Brown, OH
- Clermont, OH
- Clinton, OH
- Hamilton, OH
- Highland, OH
- Warren, OH

BEA 66 (segment): Pittsburgh, PA
- Garrett, MD
- Belmont, OH
- Harrison, OH
- Jefferson, OH
- Monroe, OH
- Allegheny, PA
- Armstrong, PA
- Beaver, PA
- Butler, PA
- Clarion, PA
- Fayette, PA
- Greene, PA
- Indiana, PA
- Washington, PA
- Westmoreland, PA
- Brooke, WV
- Hancock, WV
- Marshall, WV
- Ohio, WV
- Tyler, WV
- Wetzel, WV

Source: Robert R. Nathan Associates Inc

VI. SOURCES AND REFERENCES

A. Reports and Publications

The Aluminum Association. Aluminum Statistical Review. 1977 ed. Washington, D.C.: The Aluminum Association, n.d.

American Metal Market. Metal Statistics. 1971-78 eds. New York: Fairchild, 1971-78.

Carr, Charles C. Alcoa-An American Enterprise. New York: Rinehard & Company, 1952.

U.S. Department of Commerce. Bureau of Economic Analysis. Survey of Current Business. Washington, D.C.: GPO, 1972-78.

U.S. Department of Commerce. Bureau of the Census. Annual Survey of Manufactures. 1976 ed. Washington, D.C.: GPO, 1979.

U.S. Department of Commerce. Bureau of the Census. Census of Manufactures. 1972 ed. Washington, D.C.: GPO, 1976, Vols. II and III.

U.S. Department of Commerce. Bureau of the Census. Census of Transportation - Primary Metal Products. 1972 ed. Washington, D.C.: GPO, 1976.

U.S. Department of Commerce. Bureau of the Census. County Business Patterns. 1969-76 eds. Washington, D.C.: GPO, 1971-77.

U.S. Department of Commerce. Domestic and International Business Administration. U.S. Industrial Outlook. 1977 ed. Washington, D.C.: GPO, 1977.

U.S. Department of Commerce. Industry and Trade Administration. Directory of Aluminum Suppliers in the United States. January 1978 ed. Washington, D.C.

U.S. Department of the Interior. Bureau of Mines. Mineral Commodity Profiles-Aluminum. MCP 14. Washington, D.C.: Bureau of Mines, 1978.

U.S. Department of the Interior. Bureau of Mines. Mineral Commodity Profiles - Copper. MCP 3. Washington, D.C.: Bureau of Mines, 1977.

U.S. Department of the Interior. Bureau of Mines. Mineral Commodity Profiles - Lead. MCP 6. Washington, D.C.: Bureau of Mines, 1977.

U.S. Department of the Interior. Bureau of Mines. Mineral Commodity Profiles - Zinc. MCP 12. Washington, D.C.: Bureau of Mines, 1978.

U.S. Department of the Interior. Bureau of Mines. Mineral Facts and Problems. 1975 ed. Washington, D.C.: GPO, 1976.

U.S. Department of the Interior. Bureau of Mines. Minerals Yearbook. 1975 ed. Washington, D.C.: GPO, 1977. Vol. I.

U.S. Water Resources Council. OBERS Projections, Regional Economic Activity in the United States. Series E. 1972 ed. Washington, D.C.: GPO, 1974. Vols. I and II.

B. Industrial Shippers and Receivers

Aluminum Corporation of America, Evansville, Indiana.

Consolidated Aluminum Corp., New Johnsonville, Tennessee.

Denbo Iron and Metal Company, Decatur, Alabama.

Kaiser Aluminum and Chemical Corporation, Ravenwood, West Virginia.

St. Joseph Lead Company, Bellowsville, Pennsylvania.

Southwire Company, Hanesville, Kentucky.

Wheeling-Pittsburgh Steel Company, Pittsburgh, Pennsylvania.

DATE

FILMED

8